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TABLE OF CONTENTS.

Page.

Introduction 5

I. Notes on ships and torpedo boats 7

II. Notes on machinery 63

III. Notes on ordnance 81

IV. Notes on naval administration and personnel 161

V. Notes on electricity 185

VI. Naval maneuvers of 1891 213

VII. Armor in 1892 271

VIII. Some standard books on professional subjects 313

Index 357

INTRODUCTION.

The present volume of the Annual of the Office of Naval Intelligence is the eleventh in the series of General Information from Abroad. It is impossible for the office to supply the previous numbers of the series.

In this number the notes on ships and torpedo boats, on machinery, and on ordnance, form the principal feature. A new heading has been introduced in Chapter IV, notes on naval administration and personnel, which is a continuation of the articles which have appeared in previous numbers on the same subject.

The chapter on electricity is given this year in the form of notes on the progress made since the publication of the last volume.

Chapter VI treats of the naval maneuvers in 1891.

Chapter VII brings the armor question up to date, and is a continuation of Lieut. Southerland's article in last year's volume.

Chapter VIII is a revision of Chapter XI in No. X. This office will be glad to receive notices of errors or omissions in this list with the view to making the current bibliography of the profession as complete as possible.

It is recommended to officers and others interested in naval matters, who may have received the previous numbers of this series, to preserve the file, as back numbers can no longer be supplied, and the value of each year's volume depends to some extent on its predecessors.

C. H. Davis,
Commander and Chief Intelligence Officer.

Navy Department, *July 1, 1892.*

I.

NOTES ON SHIPS AND TORPEDO BOATS.

UNITED STATES.

The Naval Appropriation Bill for the fiscal year ending June 30, 1893, authorizes the construction of two new vessels, *Battleship No. 4*, and *Armored Cruiser No. 3.*

The sum of $9,400,000 is to be expended during the coming year on new construction.

VESSELS PROPOSED OR LAID DOWN.

CRUISER No. 13.

(Page 9, General Information Series No. X.)

The contract for this vessel was awarded to Messrs. Cramp & Sons, of Philadelphia, on August 31, 1891.

She is to cost $2,690,000 (exclusive of armament) and must be completed within two years from date of contract.

BATTLESHIP No. 4.

A seagoing coast-line battleship, with displacement of about 9,000 tons, to have highest practicable speed for vessels of its class, to cost, exclusive of armament and of premiums for increased speed, not exceeding $4,000,000.

ARMORED CRUISER No. 3.

An armored cruiser of about 8,000 tons displacement, general type of *Armored Cruiser No. 2*, to cost, exclusive of any premium that may be paid for increased speed and the cost of armament, not more than $3,500,000.

VESSELS LAUNCHED.

MONTGOMERY—DETROIT.

(Cruisers 9 and 10, page 9, No. IX.)

These vessels have been launched at the Columbian Iron Works and will probably be ready for trial next October.

Their armament now consists of eight 5-inch R. F., two 6-inch B. L., six 6-pounder, and two 1-pounder R. F., and two machine guns.

NEW YORK.

(Armored cruiser No. 2, page 8, No. X.)

Launched by Messrs. Cramp & Sons on December 2, 1891.

MACHIAS—CASTINE.

(Gunboats No. 5 and 6, page 10, No. IX.)

Launched at the Bath Iron Works December 8, 1891, and May 10, 1892.

NARKEETA—WAHNETA—IWANA.

(Steel tugs, page 10, No. X.)

Have all been launched, tried, and accepted since January 1, 1892.

RALEIGH.

(Cruiser No. 8, page 9, No. IX.)

Launched at the Norfolk Navy-Yard March 31, 1892.

Armament.—One 6-inch R. F. on forecastle; ten 5-inch R. F., two on the poop and eight on gun-deck sponsons; eight 6-pounder and four 1-pounder R. F., and two .45 calibre machine guns. Six torpedo tubes.

Protection.—Complete steel deck, 1 inch thick on the flat and 2.5 inches on the slopes; conning tower and communicating tube, 2 inches; steel on the 5-inch gun sponsons, 4 inches.

A cofferdam to be filled with water-excluding material extends fore and aft.

Motive power.—Two triple expansion engines of 10,000 I. H. P. to give 19 knots speed.

Dimensions.—Length, 300 feet; beam, 42 feet; mean draught, 18 feet; displacement, 3,183 tons.

Estimated cost, $1,642,916.

BANCROFT.

(Practice cruiser, page 8, No. X.)

Launched by Messrs. Samuel L. Moore & Sons at Elizabeth, N. J., on April 30, 1892.

TEXAS.

(Page 297, No. VII.)

Battle ship of 6,300 tons, launched at the Norfolk Navy-Yard June 28, 1892.

VESSELS LOST OR STRUCK FROM THE LIST.

Despatch.—Wrecked on the coast of Virginia, October 10, 1891.

Tallapoosa.—Sold in 1892.

Cohasset.—Sold in 1892.

TORPEDO BOATS.

No. 2.

(Page 9, No. IX.)

The Iowa Iron Works, of Dubuque, were given the contract to build this boat on October 8, 1891.

She is to cost $113,500, and must be completed in twelve months from date of contract.

BAKER'S SUBMARINE BOAT.

This boat, invented by Mr. George C. Baker, of Chicago, is built of wood and has about 75 tons displacement, which is thus divided: Hull, 20 tons; ballast, 30 tons; storage battery cells, 10 tons; engine, boiler, and gearing, 8 tons, and motor 3 tons, leaving 4 tons buoyancy. When at normal draught about 2 feet of the crown of the hull remains above water.

The principal points in which this invention differs from others that have preceded it, are that the side screws are so geared as to regulate the depth of submersion as well as to propel the boat, and the driving power is in duplicate—an electric plant and a steam plant; the former for running under water and the latter for surface propulsion, the steam engine being so arranged that it can be used to generate electricity for charging the storage batteries.

During trials which have recently taken place two men remained in the boat one hour and forty-five minutes without inconvenience.

She was frequently submerged, retaining an even keel below the surface, and answering readily to the requirements of the pilot.

Further tests will be made from time to time until the full capacity of the boat is developed.

A trial on May 24 was witnessed by the Chief of the Bureau of Ordnance. It is the opinion of the Bureau that the problem of submarine navigation and attack is approaching a solution and will play an important part in naval defensive warfare of the future.

ENGLAND.

The Net Estimated Expenditure on the Navy for the year 1892–'93 is $80,369,350.

VESSELS PROPOSED OR LAID DOWN.

From statement of the First Lord of the Admiralty:

> We have decided to make preparations for the commencement of a new scheme of shipbuilding, but for the year 1892–'93 to limit it to laying down three battle-ships. The large number of cruisers now advancing and completing have placed us in comparison with other nations, so far as this class of warship is concerned, in a favorable position.

The principal features to be embodied in the designs of new battle ships have been carefully considered by the Board, with special reference to recent foreign shipbuilding policy, and the latest developments of armament, armour, and propelling machinery. It has been decided that the introduction of quick-firing guns of large calibres, and the use of high explosives, necessitate changes in the character and distribution of the protective hull armour, and the increased protection to gun crews. It has also been determined that further steps must be taken in the direction followed in the *Royal Sovereign* and *Centurion* classes, so as to give even greater relative power and prominence to the secondary armament of quick-firing guns. In relation to the heavy-gun armaments the fullest enquiry has been made into the relative advantages and disadvantages of guns of different calibres, lengths, and ballastics, having regard not only to their powers of perforating thick armour, but to their shell fire and destructive effect against unarmoured or lightly armoured structures.

The subject of the speed and coal endurance appropriate to battle ships has been investigated, in the light of the most recent experience and of the results obtained in the extensive trials of coal consumption made on actual service during the last two years.

The new programme commences modestly, comprising at present only three battle ships and ten torpedo boats, but in the course of the next twelve months I propose to extend and elaborate a much larger scheme for submission to Parliament next year, so that the material may be bought and the arrangements made for a fresh start early in 1893–'94.

The following is a summary of the work proposed to be done during 1892–'93:

Under New Construction.—Ten vessels will be completed; 20 will be advanced sufficiently to be completed in 1893–'94; 2 ironclads will be commenced in the dockyards and 1 by contract; 10 first-class torpedo boats will be commenced by contract.

Under Reconstruction.—Five ironclads (*Rupert, Devastation, Ajax, Hercules,* and *Temeraire*) are to be finished, and 2 (*Monarch* and *Sultan*) to be advanced sufficiently to be finished in 1893–'94.

This is independent of the contract-built ships of the Naval-Defense Act, 9 of which will be completed after delivery this year, and 15 are to be materially advanced.

TORPEDO VESSELS.

(Page 15, No. X.)

The remaining vessels of this class provided for in the Naval-Defense Act have all been laid down. They are distributed as follows: The *Dryad* and *Hazard* to the Chatham and Pembroke dockyards; the *Jason*, *Niger*, and *Jaseur* to the Naval Construction and Armaments Company, of Barrow-in-Furness; the *Speedy* to J. I. Thornycroft, of Chiswick; the *Onyx* and *Renard* to Laird Brothers, of Birkenhead, and the *Halcyon*, *Harrier*, and *Hussar* to the Devonport Dockyard.

Lord George Hamilton makes the following statements concerning the *Halcyon*, *Harrier*, *Hussar*, *Hazard*, and *Dryad:*

A substantial improvement has been made in the last five of the torpedo gunboats of the Naval-Defense Act, which requires notice as illustrating my contention that it is to seagoing vessels of this type with quick-firing guns and a relatively steady platform that we must largely rely for defense against torpedo boats.

Before ordering these vessels a careful review was made of experience gained at sea with vessels of the *Sharpshooter* class. This experience was favorable, but it was obvious that substantial advantages could be gained by building the remaining five vessels of a larger size and at somewhat greater cost. This increase in size permitted of the addition of a poop, the raising of the freeboard forward, carrying with it greater fighting efficiency, a steadier gun platform, and better accommodations for officers and men, in addition to improved seagoing qualities, and a greater power of maintaining speed in rough water.

These five larger vessels, which may be named as a class after the *Halcyon*, which has been first commenced, will have the following principal dimensions: Length, 250 feet; breadth, 30 feet 6 inches; displacement, 1,070 tons; I. H. P. with natural draft 2,500, with forced draft 3,500; mean speed on measured mile with natural draft 17 to 17.5 knots, and with forced draft 19 knots.

The weight of the machinery has been considerably increased as compared with the *Sharpshooter* class, and the maximum horse power has been diminished in view of the difficulties that have occurred with the locomotive boilers of the *Sharpshooter*.

The armament will include two 4.7-inch quick-firing guns, four 6-pounders, and five torpedo tubes for 18-inch torpedoes.

In regard to the structural strength of the new torpedo vessels, Mr. W. H. White, Director of Naval Construction, made the following statements in a paper read before the Institution of Naval Architects, April 7, 1892:

Again and again have I read paragraphs stating that torpedo gunboats of the *Sharpshooter* class were being fitted with machinery and boilers of less power than were first proposed, because their structural strength was inadequate to bear the strains of the more powerful propelling apparatus. These paragraphs are absolutely incorrect. As already explained, the reduction in indicated horse power in later vessels is entirely due to unforeseen difficulties with the boilers.

Here it may be added that, having completed the steam trials of thirteen vessels of the class, and had over a year's experience at sea with one vessel, while two others have made the passage to Australia, and two to India, we have had no single report suggesting want of strength.

Troublesome vibration has occurred in two cases only, and in both of these it arose from fracture of the propeller blades, and produced no working on the structure.

Mr. A. F. Yarrow discusses the question of vibration as follows, in a paper read at the same session of this Institution:

From our experiments we have overwhelming proof that the vibration in a torpedo boat is precisely the same in extent and character when the screw is on, and the vessel driven by it through the water, as it is when the boat is stationary and the engines simply revolving without doing work, the propeller being removed. * * * It is well known that engines will impart their vibration to a boat at certain speeds much more readily than at other speeds, and it often happens that at full speed a boat may be practically steady while at a slower speed the vibration is excessive. This is dependent upon the extent to which the movements of the reciprocating parts of the engine correspond with the period of vibration of the hull, which may be considered in this investigation as an elastic body. * * *

I believe it would be by no means a difficult matter to determine in the original design, with fair accuracy, what speed of engine would be suitable to avoid vibration being set up in any given design of hull. We frequently hear of propellers being changed in order to reduce vibration and in many cases the change is made with advantage; but it often happens that the improvement is not directly due to the altered shape of the propeller, but indirectly to the change causing an alteration in the number of revolutions of the engine, and thereby preventing them synchronizing with the natural vibration of the ship. We hear of hulls being strengthened or built stronger than would otherwise be necessary with a view to reduce vibration. Doubtless this is done with more or less success; due possibly not so much to the greater strength of hull, but rather to the period of vibration being modified by this stiffening, so as to avoid its harmonizing with the movements of the machinery.

Building vessels of greater strength than would otherwise be necessary, with the object of avoiding vibration, can not be considered a scientific method of dealing with the difficulty, if it can be proved that vibration can be avoided by other means and without extra weight, because extra weight of material added to the ship tends to handicap its speed. The true cause of vibration being due to the machinery, I think it will be admitted that the correct mode of dealing with it is to so design the engines that they may be steady within themselves and free from any tendency to cause the hull to vibrate.

PIONEER—ADVENTURE.

Messrs. Yarrow & Co. are now building two screw gunboats for special service on Lake Nyassa in counteracting and suppressing the slave trade in that region. They are 75 feet in length by 12.5 feet beam, and are to have about 12 knots speed and carry an armament of light rapid-fire and machine guns. They are to be shipped in as small pieces as possible, as it will be necessary to carry them overland from the falls of the Zambezi and Shiré rivers to the lake.

WARREN HASTINGS.

The Naval Construction and Armaments Company, of Barrow-in-Furness, have recently received an order from the Secretary of State for India for the construction of a troopship.

The vessel is to be 350 feet long, 50 feet beam, and 29 feet deep, and will be fitted with two engines of sufficient power to give 17 knots speed on trial and 15 knots continually at sea.

As she is intended for service in India, all of the decks and wood fittings of every kind will be of teak, no other material being allowed in any part of the ship.

Her armament will consist of six 4.7-inch and six 3-pounder R. F. G.

VIVID.

A small steam yacht, was bought by the Government last December and is now employed in place of the old paddle steamer *Vivid* as the official yacht of the Commander-in-Chief at Devonport. She is of no value as a warship, as her speed on trial was only 11.9 knots.

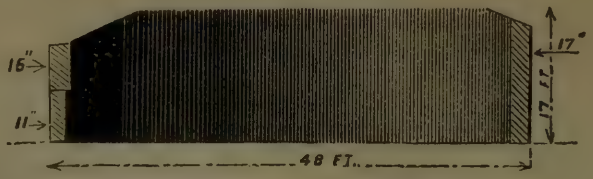
VESSELS LAUNCHED.

HOOD—RAMILLIES—REPULSE—RESOLUTION.

(Pages 87, 97, and 334, No. VIII.)

These battle ships have been launched: the *Hood* at Chatham, July 30, 1891; the *Ramillies* at the works of J. & G. Thomson, March 1;

Fig. 12.



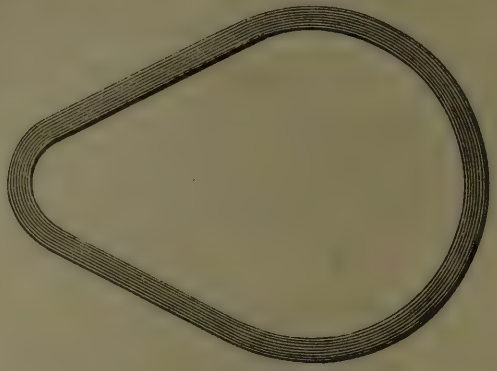
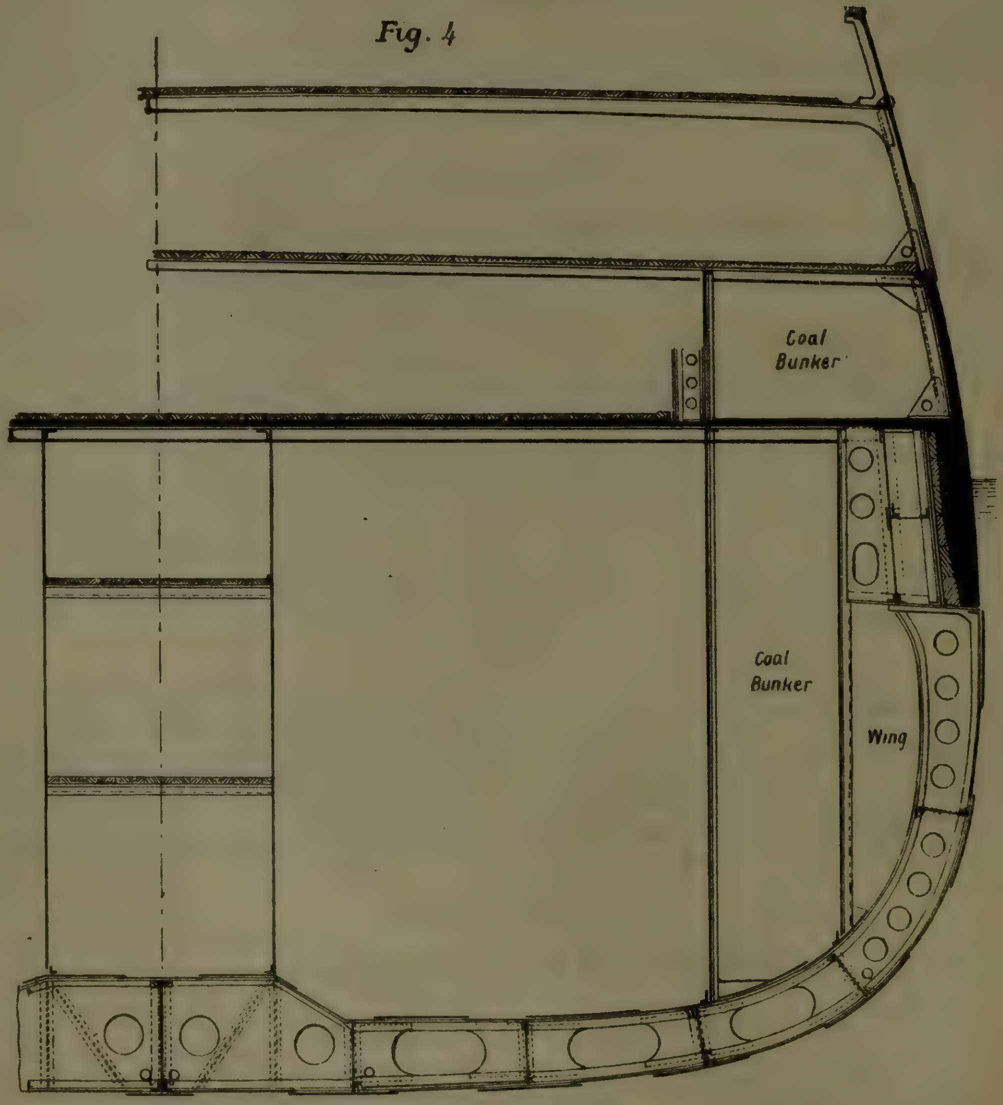


Fig. 13.

Barbettes of Royal Sovereign.

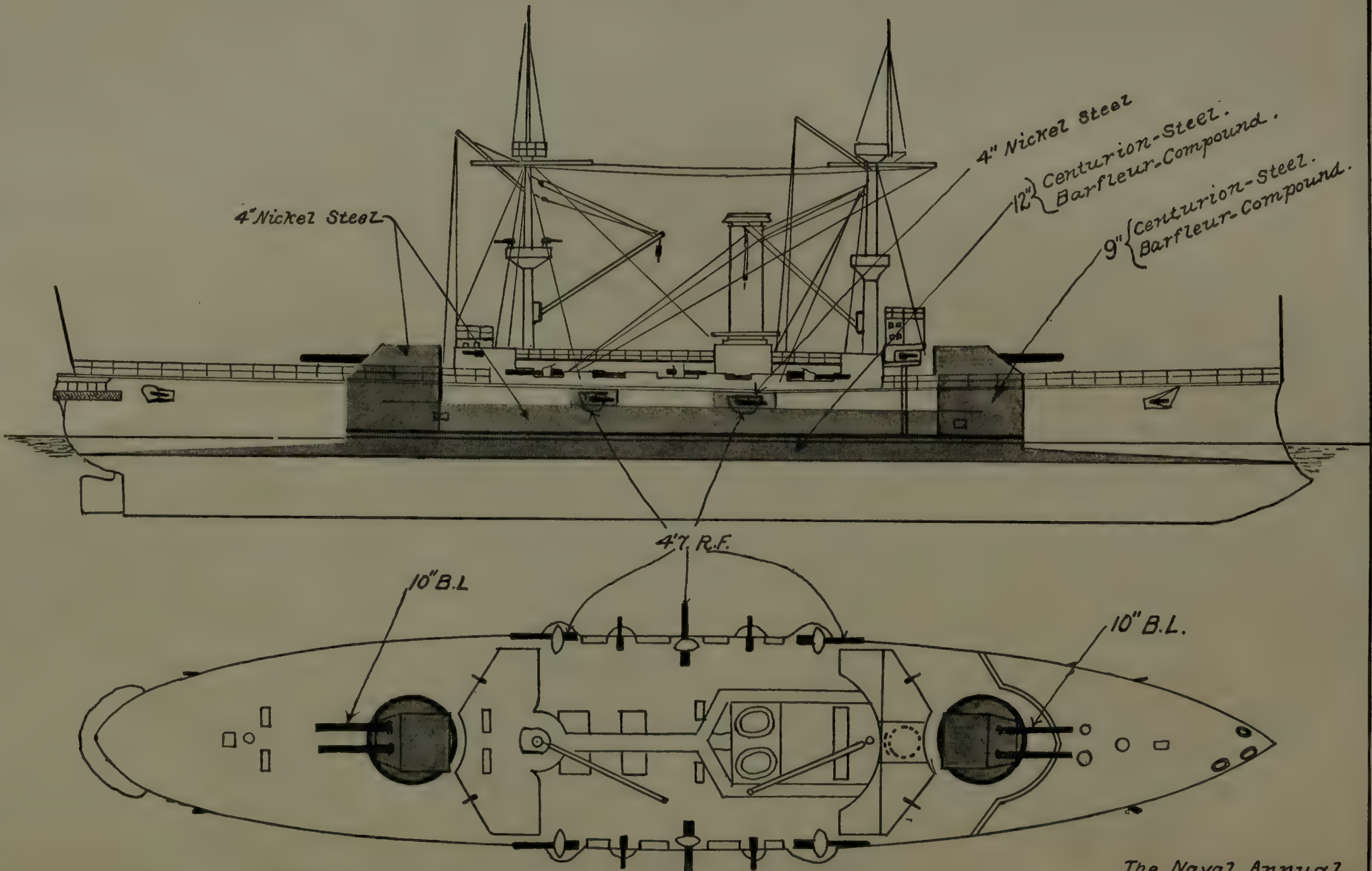
Fig. 4



Midship Section of Royal Sovereign.

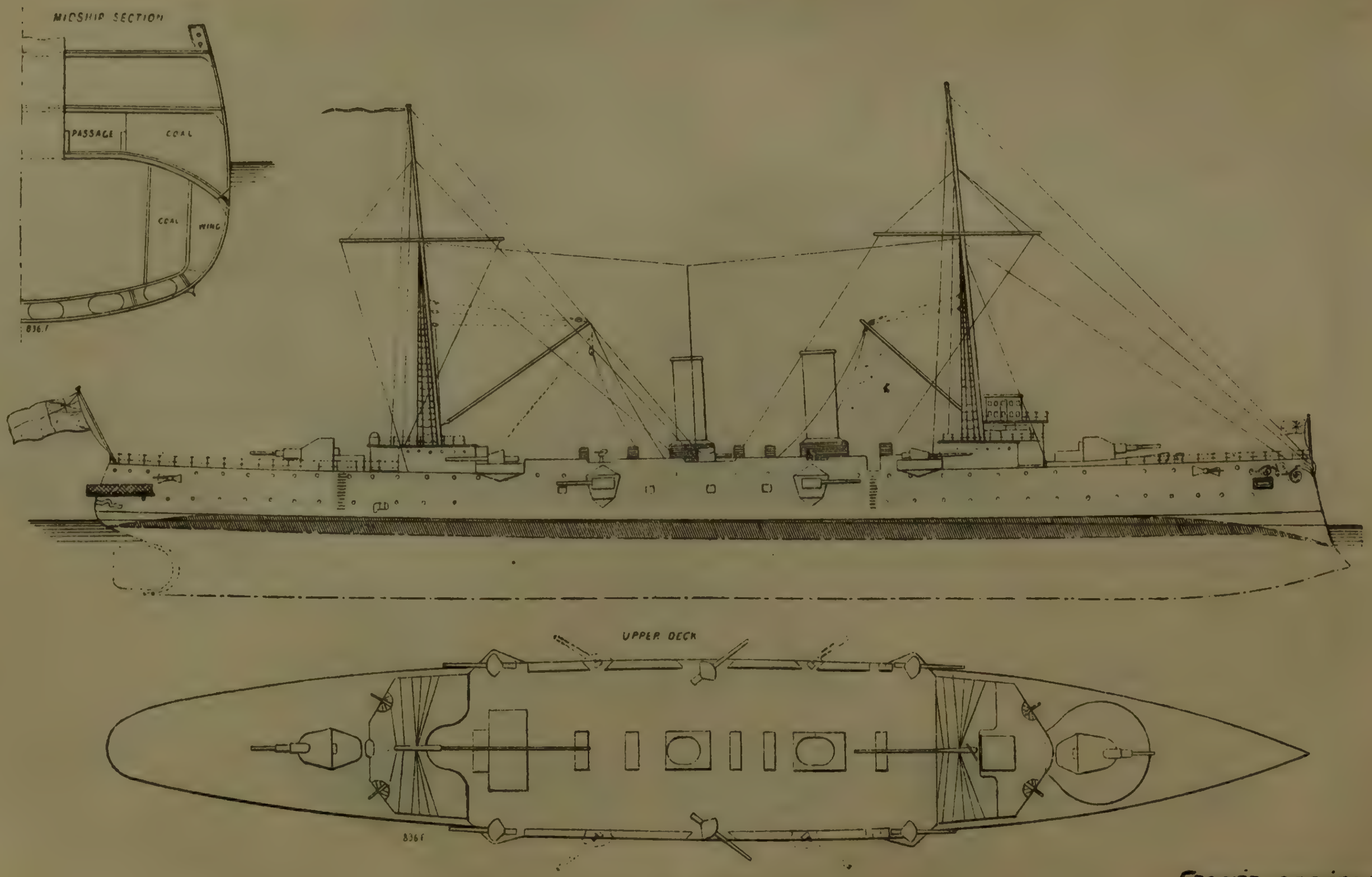
Engineering

SECOND CLASS BATTLE SHIPS.
CENTURION & BARFLEUR.


4" Nickel Steel
4" Nickel Steel
12" {Centurion-Steel. Barfleur-Compound.
9" {Centurion-Steel. Barfleur-Compound.
4'7 R.F.
10" B.L
10" B.L.

The Naval Annual
LORD BRASSEY

THE BRITISH FIRST-CLASS CRUISERS EDGAR AND HAWKE.



Engineering

the *Repulse* at Pembroke, February 27, and the *Resolution* by Palmer & Co. on May 28, 1892.

Armament.—Four 13.5-inch, 67-ton B. L., in two barbettes (except the *Hood*, which has closed turrets); ten 6-inch R. F., six on sponsons on upper deck and four in 6-inch steel casemates on the main deck; sixteen 6-pounder and ten 3-pounder R. F. and eight machine guns; seven torpedo tubes, five above and two below water.

Protection.—Water-line belt 249 feet long, 6 to 18 inches thick; bulkheads at ends of belt, 7 to 16 inches thick forward and 6 to 14 inches aft; side armor above belt, 4-inch+1-inch steel;* screens, 4-inch steel; casemates for main-deck guns, 2 to 6-inch steel; forward conning tower 12 to 14 inches and after one 3 inches; tubes, 8 inches; barbettes, 11 to 17 inches; turrets of the *Hood*, 18 inches; protective deck, 3-inch steel over top of belt and 2½ inches forward and abaft it; gun shields 4 inches.

Motive power.—Main engines of 13,000 I. H. P. to give 17.5 knots speed. (See trials of *Royal Sovereign.*)

Dimensions.—Length, 380 feet; beam, 75 feet; mean draught, 27.5 feet; displacement, 14,150 tons.

ENDYMION—GRAFTON—CRESCENT—GIBRALTAR—ST. GEORGE.

(Pages 14 and 16, No. X.)

Launched July 22, 1891, January 30, March 30, April 27, and June 23, 1892. These vessels, like the *Blake* and *Blenheim*, should be classed as armored cruisers.

Their principal characteristics are as follows:

Armament.—†Two 9.2-inch, 22-ton B. L. on C. P. mounts in bow and stern; ten 6-inch R. F. G., six on the upper deck and four in casemates on gun deck; twenty-three rapid-fire and machine guns; four torpedo tubes.

Protection.—Gun-deck casemates 2 to 6-inch, steel; conning tower, 12-inch compound; protective deck, 2 to 5 inch, steel; inclined armor about top of cylinders, 5-inch steel; ammunition tubes, 7 inches; gun shields, 3 inches.

Motive power.—Two sets of vertical triple-expansion engines of 12,000 estimated horse power, to give 19.5 knots speed. (See trials of the *Edgar.*)

Dimensions.—Length, 260 feet; beam, 60 feet; mean draught, 23 feet 9 inches; displacement, 7,350 tons.

RETRIBUTION—SCYLLA—ÆOLUS—IPHEGENIA.

The last four of twenty-one second-class cruisers (page 15, No. X) were launched during the months of August, October, and November, 1891.

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* The 4-inch plates for the *Repulse, Ramillies, Royal Oak,* and *Revenge* will be nickel steel.

† Except *Royal Arthur* and *Crescent.*

JASON—CIRCE—HEBE.

Torpedo vessels (810 tons), launched in May and June of this year.

CONSTANCE—CURLEW—CRUISER No. 3.

Small cruisers belonging to the Canadian Government. The *Constance* was launched November 12, 1891, at the Polson Iron Works, of Toronto and Owen Sound, Ontario.

She is of composite construction, steel and wood, and has the following dimensions: Length at water-line, 118 feet; beam, 19.7 feet; draught, 9.5 feet; depth of hold, 11.3 feet.

Compound engines to give, with 120 revolutions, 11 knots speed. (Fourteen knots were actually obtained on trial.)

Her battery will probably consist of three Nordenfeldt R. F. G., one on each quarter and one on the forecastle.

The Colonial Government at first intended to employ her in the fishery protection service on the Bay of Fundy, but she has been transferred to the Customs Department to be used in the St. Lawrence River, and another steamer has been built to take her place.

The *Curlew* has also been launched at this establishment, and is expected to be in commission by the 1st of June. She has the same dimensions as the *Constance*, but is to be built of steel throughout.

The Polson Company have also secured the contract for *Cruiser No. 3*, and have recently commenced her construction. She is to be similar in general characteristics to the other two vessels, but will be given more beam and less draught, as she is intended for the Georgian Bay and Lake Huron fisheries service, where she will be employed in shallow water.

COLONIAL DISPATCH VESSEL.

A twin-screw steamer, intended for dispatch service and towing, was launched on June 22, 1891, by Messrs. Gourlay Bros., of Dundee, to the order of the Colonial Government of Natal. She will be 150 feet long by 26 feet, 6 inches beam, and her engines of 1,200 I. H. P. are to give 13 knots speed. During the design the possible service of the vessel for coast defense has been provided for, as far as consistent with her immediate purposes, and she is also fitted with special pumps and apparatus for salvage operations and for extinguishing fire.

STEAM TRIALS.

An order concerning the running of steamers in hot climates has been promulgated by the Admiralty. It is to the following effect:

In ships fitted with protective decks precautions are to be taken to prevent the firerooms from becoming oppressively hot. When such vessels are running in hot climates a high rate of speed is to be avoided, and when there are twin screws and double-ended boilers it is considered that sufficient speed can be obtained by using one engine and boiler.

The temperature may also be rendered less trying by reducing the boiler pressure and keeping up sufficient steam only to enable the engines to be properly and economically worked.

Should an unusual number of men from the crew be overcome by the heat of the firerooms, a special report of the circumstances is directed to be forwarded and a full explanation given as to the speed of the vessel at the time, the number of boilers in use, the temperature of the firerooms, etc.

The defects of ventilating arrangements are also to be noted in these reports.

TRIAL OF THE CHANNEL SQUADRON.

The twenty-four hour full speed trial of this fleet took place on February 13, 1892.

The armored cruiser *Immortalité* immediately took the lead, followed by the battleships *Camperdown* and *Anson*, with the *Howe* and *Rodney* bringing up the rear. The armored cruiser *Aurora* kept up a moderate speed only, for fear of her piston-rods giving out again, while the *Howe* broke down the same evening, and arrived at Port Mahon twenty-four hours after the remainder of the squadron. The average speed of those ships which succeeded in completing the trial was as follows: *Immortalité*, about 15 knots; *Camperdown* and *Anson*, 14 knots, and *Rodney*, 13 knots.

PERFORMANCES OF THE AUSTRALIAN AUXILIARY SQUADRON.

(Pages 24 and 29, No. X.)

These vessels all made a successful passage to Australia, without any defects revealing themselves, and the machinery worked well. They experienced no rough weather, but the officers appeared convinced that they were good sea-boats, although extremely wet. The *Ringarooma*, during a three-days' trial in the Red Sea, made a speed of 13 knots on a coal consumption of 122 tons.

The *Mildura's* best run was 320 miles.

The *Wallaroo* averaged 16.4 knots on a full day's trial, her engines showing 145 revolutions. The best run made by the *Tauranga* was 318 miles. The *Boomerang* obtained a mean speed of 16.5 knots during one day.

The *Karrakatta's* best day was 312 miles. Her condenser tubes leaked, but were repaired on the voyage out.

ROYAL SOVEREIGN.

The eight battle ships of this class surpass in size and power any previously constructed for the British navy, and it was therefore deemed prudent to push the *Royal Sovereign* to completion as rapidly as possible in order that the experience gained on her trials might be available before the completion of her sister ships.

She was laid down in September, 1889, and her natural draft trial took place on April 19, 1892, the ship being completely coaled, with all her guns on board and practically ready for sea.

The following very good results have been reported: Boiler pressure, 150.3 pounds; air pressure, 0.39 inches; vacuum, 28.3 inches; revolutions, 96.8; I. H. P., 9,644.

The speed was measured in several ways. She first proceeded out to sea and ran four times over a 9½-mile course, the result being a mean of 16.31 knots with 9,444 I. H. P. Four runs were then made on the measured mile, when a speed of 16.77 knots was obtained with 9,760 I. H. P. Finally the patent log registered a mean speed of 16.4 knots during the eight hours' steaming.

The weight and stiffness of the ship prevented any vibration, and her steadiness was remarkable. She answered readily to five degrees of helm, and in deep water gave no trouble, but in shallow water she dragged considerably and required constant watching. Her draught was 27 feet forward and 28 feet aft.

The forced draft trial, which took place on April 21, was also considered as very satisfactory, although there was some priming during the fourth hour and a slight leakage of tubes in two of the boilers, which caused a loss of power, but was not of sufficient importance to arrest the trial. As the engines had worked in a most satisfactory manner, the last hour was thrown out in calculating the results of the steaming, and the consequent data were as follows: Boiler pressure, 155 pounds; air pressure 1.6 inches; vacuum, 27.8 inches; revolutions, 106.3; I. H. P., 13,312; speed, 18 knots.

As no dependence could be placed upon the record of the patent log, the rate of speed was calculated on the basis of the results obtained from the previous runs on the measured mile with natural draft, and this calculation was verified by observations of the navigating officer.

(For gun trials of this vessel see Notes on Ordnance.)

The leakage of boiler tubes became quite serious after the conclusion of the above trial, and the Admiralty have decided to fit to them the new ferrules which have proved so successful on board the *Barracouta*.

HERCULES.

This battle ship having been fitted with new engines and boilers, was given an eight-hour trial with natural draft on June 7. The results were very satisfactory, as a mean speed of 14.4 knots was obtained with 7,363 I. H. P. and 81.6 revolutions. (7,000 H. P. and 14 knots required).

THUNDERER.

An eight-hour natural draft trial of this battle ship took place on June 23, with the following mean results: Boiler pressure, 137 pounds; revolutions, 90; vacuum, 28.3; I. H. P., 5,964; speed, 13.5 knots.

The results of ferruling her boiler tubes appear to be so far very satisfactory. It is reported that not a tube leaked nor a ferrule started during the trial, but an examination afterwards showed that a few combustion chamber stays and some saddle plate seams were leaking slightly. Subsequent forced draft trials were also successful; a mean of 7,066 I. H. P. was obtained with 96 revolutions and 1.96 inches air pressure; speed, 14.3 knots.

BLAKE—BLENHEIM.

(Page 15, No. X.)

The official natural-draft trial of the *Blake* took place on November 18, 1891, and gave the following average results during a seven-hour run: Boiler pressure, 125.5 pounds; air pressure in fire rooms, 0.42 inch; revolutions, 89; vacuum, 28.2 inches; collective I. H. P., 14,525.

Four runs were made on the measured mile, with and against the tide, the mean speed being 19.12 knots.

The average speed of the seven hours' steaming as measured by patent log was 19.28 knots, which fell short by over three-quarters of a knot of what was anticipated in proportion to the power indicated by the engines.

Up to the limit of air pressure used the boilers answered admirably, but no attempt was made to press them under forced draft, the ship being at once accepted from the contractors and prepared for commission.

Several reasons have been given for this failure, but there can be little doubt that it was due in part to the fact that her boilers had been fitted with a common combustion chamber. Beyond this point authorities disagree, some claiming that insufficient weight and space had been allowed to the boilers, and others that it was due to the ship having been run in shallow water.

Mr. W. H. White, Director of Naval Construction, makes the following statements in a paper read before the Institution of Naval Architects, April 7, 1892:

> This trial was made chiefly to determine the behavior of the boilers, when working at the highest limit of power likely to be reached on service. Before the trial began it was known that the thrust bearing required adjustment, and the consequent waste of power made the trial no true test of the performance of the vessel as regards the ratio of speed to power. Moreover, the shallow water on the greater portion of the distance run during the trial caused a serious degradation of speed. * * *
>
> Naturally, the discrepancy between estimates and performance gave rise to unfavorable criticism, since the facts to which reference has been made—excessive waste work on friction of thrust and drag, due to shallowness of water—were not generally known. Throughout, I felt confident, however, that these losses fully accounted for the falling off in speed, and this opinion has since been proved correct.
>
> It was important to commission the *Blake* as soon as possible, consequently no repetition of the trial was proposed for her, since the sister ship *Blenheim* was soon to be ready for trial. * * *

> In February last the *Blenheim* was run in deep water off Plymouth with three boilers only, out of six large boilers and an auxiliary boiler.
>
> She ran for two hours, developing a little over 9,800 horse power, the mean speed being 19.05 knots. This is a startling contrast to the figures above given for the *Blake* at practically the same speed, for it will be seen to vindicate a saving of over 5,000 horse power, out of the total power (14,500 horse power) developed in the *Blake*. The forms of the ships are identical; they were both tried at deep-load draft, and, although the screws are not identical, they are probably nearly equal in efficiency. No doubt the waste of power on friction of thrust bearings in the *Blake* and the drag of shallow water produced this serious loss.

During the discussion of Mr. White's paper several other authoritative statements were made in regard to the retardation of a vessel's speed in shallow water, and the general conclusion arrived at, was, that in order to obtain a fair comparison of the performances of war ships they should all be run in deep water, over the same course.

The *Blenheim*, like her sister ship, has double-ended boilers, but the furnaces have separate combustion chambers.

The contractor's eight hours' trial with natural draft took place in January, 1891, and gave the following excellent results: Boiler pressure, 144.7 pounds; air pressure, 0.28 inches; revolutions, 94.6; vacuum, 27.5 inches; collective I. H. P., 14,924.54; mean speed by log, 20.4 knots.

There was a slight leakage in the forward boilers.

On February 16 the *Blenheim* was put through a series of progressive trials, with the object of determining the relation of power to speed.

The results proved very satisfactory as regards the coefficients between the vessel and her engines. With 39 revolutions and 1,028 I. H. P., a mean speed of 8.334 knots was obtained; 50 revolutions and 2,079 H. P. gave 11 knots; 66 revolutions and 4,877 H. P. gave 14.64 knots, and 84 revolutions and 9,758 H. P. gave 18 knots.

After testing her anchor and steering gear she proceeded to Plymouth for her forced-draft trial, which has been thus reported upon by the First Lord of the Admiralty:

> Before attaining the full power she covered 23 knots in one hour and four minutes, when a leakage occurred in the after boilers, which previously had worked well.
>
> As the forward boilers, which leaked on the natural-draft trial, showed no indication of weakness, it was determined to put these alone under forced draft. This was done for five hours, and a speed of 19 to 19.5 knots was obtained with 10,000 I. H. P.
>
> The boilers were double-ended, but with separate combustion chambers.
>
> Further experiments will be made in the direction of trying a new kind of tube-fitting, and the technical experts of the Admiralty are hopeful of overcoming the leakage of the tubes, which has hitherto baffled them.

EDGAR—HAWKE.

(Page 16, No. X.)

The following reports show that the trials of these cruisers have given very good results:

EDGAR.

	Date.	Revolutions.	Speed.	I. H. P.
Trials off Plymouth:			*Knots.*	
Natural draft	Nov. 4, 1891	99.2	19.25	10,200
Full power	Nov. 19, 1891	104.5	20.97	12,550
Progressive trials on measured mile at Stokes Bay:				
Ten knots	Nov. 24, 1891	45.3	9.647	820
Twelve knots	do	55.9	11.87	1,690
Thirteen knots	Nov. 27, 1891	63.1	13.4	2,464
Fourteen knots	Nov. 24, 1891	65.9	14.015	2,997
Sixteen knots	Nov. 27, 1891	79.3	16.512	5,102
Eighteen knots	do	92.8	18.836	8,520
Full speed	do	106.2	20.488	13,260

HAWKE.

March 5, 1892: Time, 8 hours; air pressure, 0.3 inch; revolutions, 98.46; I. H. P., 10,761; speed, 19.5 knots.

March 8, 1892: Time, 4 hours; air pressure, 0.44 inch; revolutions, 102.18; I. H. P., 12,521; speed, about 20 knots.

Both of these vessels were engined by the Fairfield Shipbuilding and Engineering Company.

VULCAN.

(Page 20, No. X.)

[From First Lord's statement.]

The *Vulcan* passed an eight-hours' natural draft trial most satisfactorily, both as regards speed and power indicated; but in carrying out a series of progressive trials with lower powers and pressure there was serious leakage in the tubes of two boilers.

The boilers are double-ended and they have a common combustion chamber. In the *Thunderer* our experience has been similar. * * * A considerable number of smaller vessels, similarly boilered to the *Vulcan*, have passed their natural draft trials, and are now working satisfactorily in commission, but the application of forced draft beyond a certain pressure is forbidden in their stokeholds. Without attempting to give any technical or scientific explanation of the origin of these boiler troubles, it is clear to me that they can be prevented for the future by increasing, as has latterly been done, the weight and capacity of the boilers. The extreme application of forced draft, single combustion chambers in double-ended boilers, are ingenious devices for diminishing the weight of the boiler in proportion to the *maximum* power to be obtained from it.

I am far from asserting that, as further data and experience are obtained, these and other contrivances may not be recognized as safe and legitimate improvements in war ships, but in the meantime the gain obtained is not commensurate with the risk incurred. The first double-ended boilers with single combustion chambers fitted in two of the belted cruisers gave good results; since then similar types of boilers in other ships have been a constant anxiety. * * *

Until the result of further experiments is known, I do not propose to reboiler either the *Vulcan* or the *Thunderer*. (See notes on *Barracouta*.)

LATONA—TERPSICHORE—MELAMPUS—ANDROMACHE—THETIS—TRIBUNE—NAIAD—APOLLO—SIRIUS—INDEFATIGABLE—PIQUE—SPARTAN—SYBILLE—INTREPID—RAINBOW.

(Page 16, No. X.)

The first three of these cruisers were tried last year, but it has been thought well to collect all the data concerning the *Apollo* class in one table for the sake of convenient comparison.

Latona and *Terpsichore.*—Mr. White, Director of Naval Construction, speaks as follows:

> Of the second class cruisers, two have been tried for speed at deep load draft, viz, the *Latona*, which was first completed and was tried on the measured mile at Stokes Bay, and the *Terpischore*, which was put through a series of progressive trials on the deep-water measured mile at Skelmorlie (Firth of Clyde). The *Latona* realized 20.112 knots with 9,600 H. P., the power realized for four hours being 9,455. She also made 19.05 knots for 7,400 H. P. in the course of the eight hours' natural draft trial. These results were affected, as explained hereafter, by the shallowness of water at Stokes Bay in relation to the high speeds obtained.
>
> This led us to arrange to try the sister ship *Terpsichore* in deep water. She attained 20 knots with 8,700 H. P., which represented a gain of about *four-tenths* of a knot, due to greater depth of water.

(For other details of these trials see page 21, No. X.)

Naiad.—The engine seating and bottom structure of this cruiser have been considerably strengthened so as to prevent vibration; and in order to test various expedients for the purpose of avoiding the persistent scoring of the crosshead brasses, which has manifested itself in all cruisers of her class, two of the brasses have been coated with white metal, and in two other cases the pins are of iron instead of steel.

A great diminution of vibration was noticed and an examination of the crossheads after the trial showed that the iron gudgeons were in much better condition than the steel ones.

Sirius.—During the forced-draft trial the sea was rough and the wind about force 6 by Beaufort scale.

Indefatigable.—The first attempt at a forced-draft trial was unsuccessful owing to the fact that the boilers failed to supply sufficient steam. A number of the grate bars were removed to facilitate combustion and a second attempt gave better results, but still not satisfactory.

The mean collective I. H. P. was 8,455, with 1.09 inches air pressure, Two runs on the measured mile gave a mean speed of 19 knots.

A third and final trial took place on February 4, 1892, when the guaranteed horse power was exceeded, and the other results sufficiently satisfactory to warrant the vessel's acceptance.

The *Indefatigable*, like the *Blenheim*, has boilers of the improved Admiralty type, which have separate combustion chambers.

Pique.—The natural-draft trial was run in a moderately rough sea, and the forced-draft run was also made in unfavorable weather, the wind having a force of from 5 to 7.

These trials being satisfactory, the engines were about to be formally accepted, when serious defects were discovered in two of the furnaces, rendering it necessary to renew them.

Spartan.—Excellent results. The forecastle of this cruiser has been strengthened to withstand the concussion from the 6-inch gun which is mounted upon it, and the after part of the ship is being supported by about thirty iron stanchions. This course has already been adopted in the case of the *Sirius*, and if successful, will be applied to all ships of this class.

Sybille.—Excellent results as regards speed and power, but since the trial, five of her furnaces have developed cracks, and will probably have to be renewed.

Intrepid.—Boiler tubes leaked badly and bearings heated during the first natural-draft trial on May 4, and several other attempts have also proved unsuccessful. At last accounts her boilers were being repaired.

DATA OF TRIALS OF THE *APPOLLO CLASS* PROTECTED CRUISERS.

[The 3,600-ton ships are sheathed.]

Name of ship.	Displacement.	When tried.	Forced draft (time four hours).								Natural draft (time eight hours).							
			Ship's draught.								Ship's draught.							
			Forward.	Aft.	Air pressure.	Boiler pressure.	Vacuum.	Revolutions per minute.	I. H. P.	Speed.	Forward.	Aft.	Air pressure.	Boiler pressure.	Vacuum.	Revolutions per minute.	I. H. P.	Speed.
			Ft. In.	*Ft. In.*	*In.*	*Lbs.*	*In.*			*Knots.*	*Ft. In.*	*Ft. In.*	*In.*	*Lbs.*	*In.*			*Knots*
Latona	3400	Feb. 1891	*15 6	17 6	1.25	152	26.5	145	9,455	20.115	(*)	(*)	(?)	153	28	136	7,400	19.05
Terpsichore	3400	May 1891	(*)	(*)	(?)	145	(?)	137	8,820	20	(*)	(*)	(?)	140	(?)	127	7,133	18.6
Melampus	3400	June 1891	....	....	1.28	147	26.5	141	9,093	18.35	....	....	(?)	147	27.5	135	7,656	18
Andromache	3400	July 1891	....	....	(?)	(?)	(?)	(?)	9,044	20	....	....	(?)	(?)	(?)	(?)	7,234	(?)
Thetis	3400	Sept. 1891	....	....	.75	149	27	136.2	9,496	(?)	....	....	.55	137.2	27.4	136.1	7,033	(?)
Tribune	3400	Sept. 1891	....	....	.6	(?)	(?)	137.8	9,102	20	....	....	.25	149	(?)	130.3	7,523	18.5
Naiad	3400	Oct. 1891	14 2	17 6	1.2	150	25.1	145.5	9,250	19.24	....	....	.4	153	(?)	136	7,521	18.6
Apollo	3400	Oct. 1891	....	....	.82	151.4	26.5	138.3	9,226	(?)	....	....	.3	150	(?)	130	7,488	19
Sirius	3600	Oct. 1891	15 3	18 6	.81	150	26.6	142.5	9,281	19.35	15 2	18 5	.29	143	27	132	7,491	19.18
Indefatigable	3600	Jan. 1892	15 0	18 6	.02	135.9	25.7	137.5	9,045	19.75	15 0	18 6	.47	135	27	127	7,321	18.74
Pique	3600	Jan. 1892	....	....	1.05	145	27.8	138	9,154	19.6	....	....	.28	145	28.5	128	7,471	18.5
Spartan	3600	Feb. 1892	....	....	.92	148	27.8	141.7	9,205	20.44	....	....	.33	139.3	(?)	(?)	7,709	19.7
Sybille	3400	Mar. 1892	....	....	.48	149	27.9	145	9,400	20.5	....	....	.10	(?)	28.7	135.2	7,632	19.3
Intrepid	3600	May 1892	....	....	....	....	....	....	....	....	....	....	.31	(?)	27	128	7,219	19.02
Rainbow	3600	May 1892	....	....	.7	....	....	....	9,681	20.2	....	....	.32	....	28.5	....	7,780	19.45

*Load draught.

BARRACOUTA.

(Page 19, No. IX and p. 27, No. X.)

Experiments which have been recently completed on board of this cruiser seem to have solved the leaky-tube problem, at least in her own case.

The boiler tubes having been fitted with a special kind of ferrule made at Chatham dockyard, an eight hours' trial under forced draft gave most satisfactory results, the engines being driven with safety to almost double the contract horse power.

On the strength of this success, the boilers of the *Royal Sovereign*, *Thunderer*, *Devastation*, and *Vulcan* are to be fitted in the same manner and thoroughly tested. (See trial of Thunderer.)

PALLAS—PHŒBE.

(Pages 16 and 24, No. X.)

The commission trial of the *Pallas*, took place in September, 1891, but resulted in a break-down; the new crosshead brasses, with which she had been recently fitted, giving out.

On opening out the brasses they were found to be grinding away. The gudgeon pins were of steel, and although the lubrication was perfect, the brasses were literally crumbling into dust and the pins wearing very badly.

(This experience strengthens the conclusion that iron pins are better than steel ones for this purpose. See trials of the *Naiad.*)

The preliminary trial of the *Phœbe*, which took place on July 30, was not successful. The engines worked smoothly for two hours, and developed during this time 5,080 I. H. P., but the vacuum in the starboard engine could not be maintained above 23 inches.

A forced draft trial on August 24 was brought to a premature conclusion by the occurrence of a small back draft in the two after boilers. Flame issued from the furnaces and four men were slightly injured.

The horse power decreased from 7,250 at the end of the fourth half hour to 7,000 at the end of the seventh half hour, when the trial was abandoned.

Leaky boiler tubes caused this accident, and in order to prevent this in the future some of the tubes were removed and a few stays taken out to eliminate the rigidity of the boilers. To prevent flame entering the fire-room automatic draft plates were fitted to the ashpits.

Under these improved conditions the final trial of the *Phœbe* was successful, and gave the following good results: Boiler pressure, 149 pounds; air pressure, 1.8 inches; vacuum, 24.9 inches; revolutions, 155.7; I. H. P., 7,535; speed, 19 knots in a stiff breeze and rough sea.

GOSSAMER—GLEANER—ASSAYE—PLASSY—SPEEDWELL.

The *Gossamer* having been selected as an example of the numerous vessels of her type for experiment was given a series of progressive trials with different forms of propellers, and after the conclusion of these tests she was driven to ascertain the utmost results as to power and speed which it was possible to obtain from her.

With 1.5 inches air pressure the mean power developed was 3,600 and the average speed 19.8 knots (considerably below the estimates), and as her boilers exhibited signs of weakness at the conclusion of the run it was evident that they had been pressed to the limits of their endurance.

The *Gossamer* is now (June, 1892) being prepared for what may prove to be very important experiments.

She is being fitted to give the induced draft system a thorough trial before a Committee appointed by the Admiralty to inquire into the defects of modern boilers and to suggest a remedy.

Gleaner (built and engined at Sheerness dockyard) has been quite successful.

Natural draft trial, November 6, 1891: Time, 8 hours; I. H. P., 2,606; speed, 17.6 knots.

Forced draft trial, December 21, 1891: Time, 3 hours; I. H. P., 3,631.6; revolutions, 249.6; speed, 20.1 knots.

Assaye.—Commission trial, February 3, 1892: Time, 8 hours; boiler pressure, 116 pounds; revolutions, 226; I. H. P., 2,396; speed, 16.5 knots.

Plassy.—Has been finally successful in obtaining 2,484 I. H. P., and 16.6 knots with natural draft. The engines have been stayed through the bunkers to the sides of the ship, thus doing away with the excessive vibration, which on a former trial broke both intermediate steam pipes.

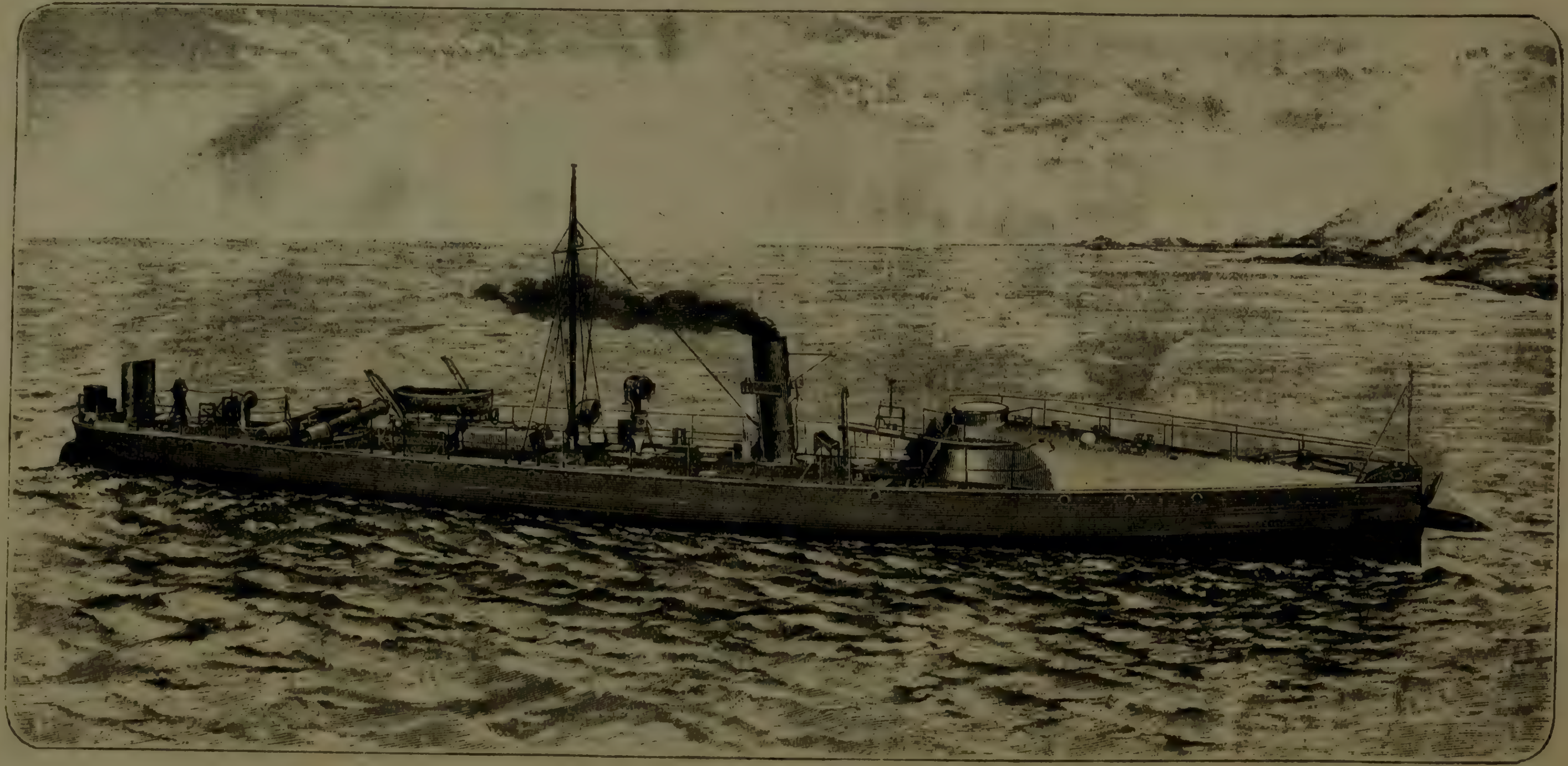
Speedwell.—New shaft bearings which were put in last November have given excellent results, and have been thoroughly tested during her recent six months' cruise. These bearings were composed of two kinds of white metal, and it was found by experiment that the softer of the two was the more durable. The starboard bearings, which had a larger proportion of the hard metal, are now being altered accordingly. This composition appears fully capable of withstanding the friction due to a large number of revolutions, and the bearing difficulty is said to have been at length overcome in a satisfactory manner. (See trials of *Speedwell* and *Karrakatta*, pages 28 and 29, No. X.)

VESSELS LOST OR STRUCK FROM THE LIST.

Bellerophon, hulk, sold in 1892.
Cambrian, frigate, to be sold.
Algerine, screw gun vessel, sold.
Harpy, paddle tug, to be sold.
Ranger, gun vessel, to be sold.
Dragon, screw composite sloop, to be sold.
Griffon, gun vessel, sold in 1892.
Pegasus, sloop, to be sold.
Volcano, steam frigate, to be sold.
Columbine, sloop, sold.
Swinger, gun vessel, to be sold.
Enterprise, Colonial gun vessel; lost in a cyclone November 2, 1891, at Port Blair, Andaman Islands.

FIRST-CLASS TORPEDO BOAT FOR THE VICTORIAN GOVERNMENT.

CONSTRUCTED BY MESSRS. YARROW AND CO., ENGINEERS, LONDON.



Engineering.

Britomart, gun vessel, sold in 1892.
Tyrian, hulk, to be sold.
Opal, screw cruiser, to be sold.
Turquoise, screw cruiser, to be sold.
Sapphire, screw cruiser, to be sold.
Procris, hulk, to be sold.
Jumna, troopship, to be sold.
Orontes, troopship, to be sold.
Miranda, screw cruiser, to be sold.

The cruiser *Shah* has been converted into a coal hulk and stationed at Bermuda.

The old armor-clad *Defence* has been converted into a floating factory for the instruction of machinists.

The gun vessels *Flamingo* and *Wanderer* have had their engines and boilers taken out; the former being fitted as a coal hulk, and the latter as a training ship for apprentices.

TORPEDO BOATS.

No new boats have been constructed for the Home Government during the past year, except a number of 30-foot cutters or vedette-launches, which have not proved very successful.

The First Lord of the Admiralty makes the following statements regarding his policy in torpedo boat construction:

> A torpedo boat is essentially the weapon of the weaker, and of the assailant rather than the defender of commerce. Protection against such boats and their attack must be looked for in the development and increased accuracy of machine and quick-firing guns, mounted in vessels capable of keeping the sea in rough weather. The Admiralty have, during the last few years, built a considerable number of such vessels, and they believe that as a protection they will be superior to any accumulation of mere torpedo-boats, and will be useful both as scouts and dispatch vessels.
>
> Recognizing, however, the great improvements that have taken place in first-class torpedo boats during the last few years, they propose to build ten such boats by contract.

STEAM TRIALS.

The official trial of a sea-going torpedo boat built by Messrs. Yarrow for the Victorian Government, took place in August, 1891. It consisted of a three hours' full speed run, and, although it took place during exceptionally rough weather the following very good results were obtained:

Steam.	Vacuum.	Revolutions per minute.	Time.		Speed.	Admiralty mean.
Pounds.	*Inches.*		*M.*	*Sec.*		*Knots.*
165	23	405	2	27	24.489	22.736
165	23	413	2	51	21.052	
165	23	400	2	28	24.324	
165	23	410	2	50	21.176	
165	23	403	2	28	24.324	
165	23	404	2	50	21.176	

The foregoing table gives the result of six runs over a measured mile. The mean speed during the three hours was taken from the number of revolutions made during the entire run, and was found to be 22.566 knots, omitting a slight allowance that should be made for a reduction in revolutions at the time of turning. Her manœuvring powers were found to be equally satisfactory, and there was no trouble from hot bearings or leaky tubes.

This boat is said to be a good example of the latest practice, and to embody in its design the results of practical experience gained by the use of such craft in the British navy. It is very similar to the six vessels that were built by the same firm for the Admiralty three years ago, and the following particulars concerning her are given as supplementary to the description of those boats on page 439, No. VIII.

She is built of galvanized Siemens steel, and is divided into a number of water-tight compartments, any two of which may be open to the sea without losing all reserve of buoyancy. The bulkheads are without openings, so that water-tight doors are not fitted.

Steam is supplied by a boiler of the locomotive type, which bears 170 pounds working pressure, and is fitted with the builder's water-tight ash pan.

The main engines are of the three-stage compound type, and develope 1,150 I. H. P. when running in full gear.

The bunkers hold about 20 tons of coal, which is considered sufficient for a run of 1,600 miles at a 10-knot speed.

The armament consists of a bow torpedo tube, built into the stem for firing in a line with the keel, and two divergent torpedo guns on a turn-table aft.

Provision is also made for three R. F. G., which are to be mounted when the boat arrives in Australia.

The search light is placed on a stand just forward of the signal mast, but it is capable of being moved, and arrangements are made for fitting it on either of the gun stands, or on top of the conning tower, leads being provided to conduct the current to whichever position may be considered desirable at the time.

PATHAN—KAREN—BALOOCHI.

These three boats had successful trials off Bombay, India, in May, 1892. The *Pathan* is said to have made 24 knots.

FRANCE.

The Naval Estimates for 1892, as presented by the Budget Committee and finally passed, amounted to $43,986,654, of which $11,094,540 were for new construction. An additional sum of $1,600,000 was also granted for the rearmament of the fleet with rapid-fire guns, and a Supplementary Estimate of $8,162,396 presented by M. Cavaignac, the present

Minister, will, if granted, bring the total expenditure in 1892 up to $53,749,000.

The Estimates for 1893, as recently submitted, amount to $49,348,151.

The following extracts are from reports of M. Barbey, the late Minister of Marine, in which he outlines the policy which, in his opinion, should govern the construction of new ships in the future:

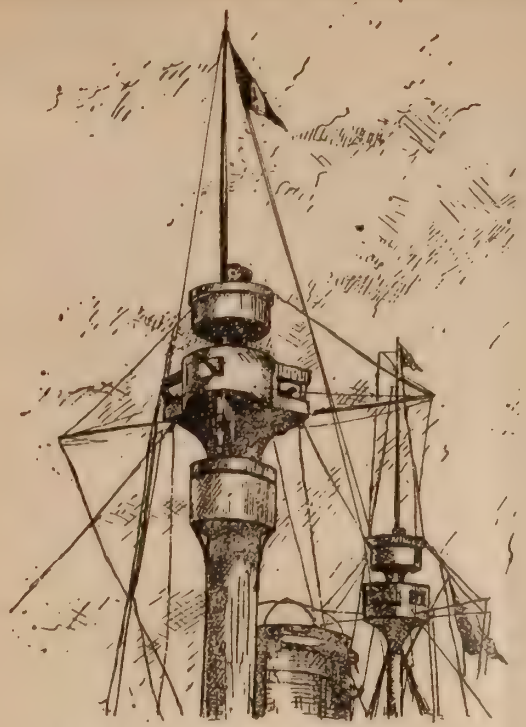
> In studying the age and condition of war vessels now on the navy list, it is discovered that 81 ships will disappear during the next decennial period, and in order to supply this waste and maintain the navy at the rank it ought to occupy the new programme provides that within ten years 81 vessels shall be built, including 10 armor clads, 50 swift cruisers, and 21 torpedo vessels, transports, torpedo boats, etc.
>
> For the execution of this programme a period of ten years has been adopted in order not to make the burden too heavy during any one year and in order not to be obliged to ask extraordinary appropriations.
>
> Each year the eight vessels to be commenced will be put in the Budget and advantage will be continually taken of any new inventions which may occur to modify the provisions of the Superior Council.
>
> * * * * * * *
>
> In considering the plans for new ships the endeavor has been:
>
> (1) To augment as much as possible the rapidity of heavy-gun fire, all progress in this direction being an addition to the offensive power.
>
> (2) To assure the greatest possible protection to both personnel and *matériel*, against shells loaded with powerful explosives, the use of which is becoming general.
>
> (3) To place on our ships the greatest possible number of rapid-fire guns, in order to establish the superiority of this fire at the commencement of a combat.
>
> (4) To provide an efficacious and convenient arrangement for supplying the rapid-fire guns with ammunition, in order to be able to profit by their effective fire during the whole engagement.

VESSELS PROPOSED OR LAID DOWN.

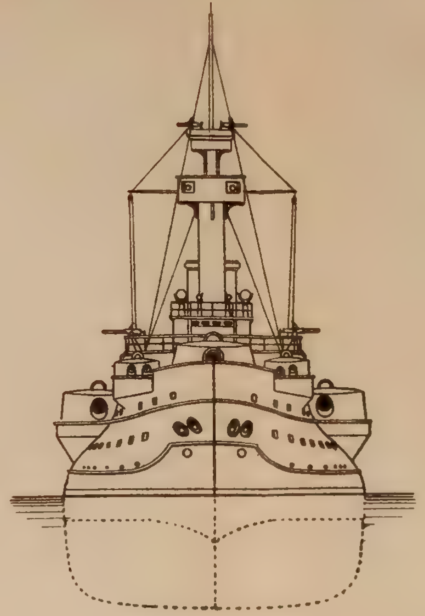
In pursuance of the above policy it is proposed to lay down the following warships during 1892:

Number of vessels.	Type.	Displacement.	Armament.	Speed.		Steaming radius.	Armor.	Cost.
		Tons.		*n.*	*f.*		*Inches.*	
2	Battle-ships—type, Charles Martel; (A) to be built by the Government, and (B) by contract; (named Bouvet and Masséna).	*12,000	Two 11.8-inch B. L., two 10.6-inch B. L., eight 5.5-inch R. F., twenty-six lighter R. F.	17	18	4,000 miles at 10 knots; bunker capacity for 5,000.	†17.72	$5,475,000 5,388,000
1	First-class protected cruiser (C); type, Charner, improved by the adoption of more rapid-fire guns and an increased coal supply; (named Pothuan).	*5,000	Two 7.5-inch B. L., six 5.5-inch R. F. (Smaller R. F. guns not yet determined.)	18	19	....	....	2,149,200
1	Third-class protected cruiser (D); type, Surcouf improved; (named Linois).	2,204	Four 5.5-inch R. F., two 3.9-inch R. F., eight lighter R. F.	18	20	....	....	895,600
2	Cruisers for distant service (E) and (F) to replace those of the Lapérouse type.	3,900	Four 6.3-inch, ten 3.9-inch R. F......	18	19	5,500 miles at 10 knots; bunker room for one-third more.	....	1,400,000
1	Torpedo depot-ship; (named Foudre)	6,000	....		18	6,000 at 10 knots, with bunker capacity for 9,000.	....	2,186,000
1	Torpedo vessel; (named Cassini)	925	One 3.9-inch R. F., three 65-millimetre R. F., four 37-millimetre R. F.		21	3,500 miles at 10 knots; bunkers for one-third more.	....	589,000
10	First-class torpedo-boats (Nos. 182 to 191, inclusive).	....	....	....		....	....	....

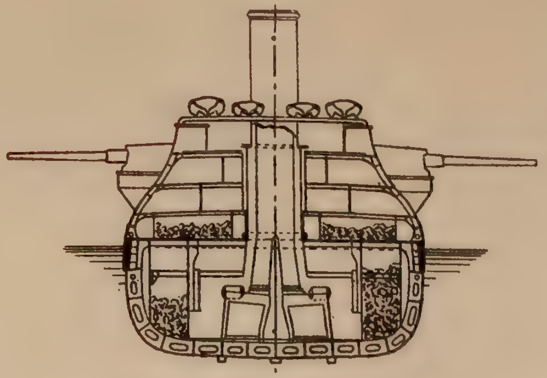
* About. † Maximum thickness.



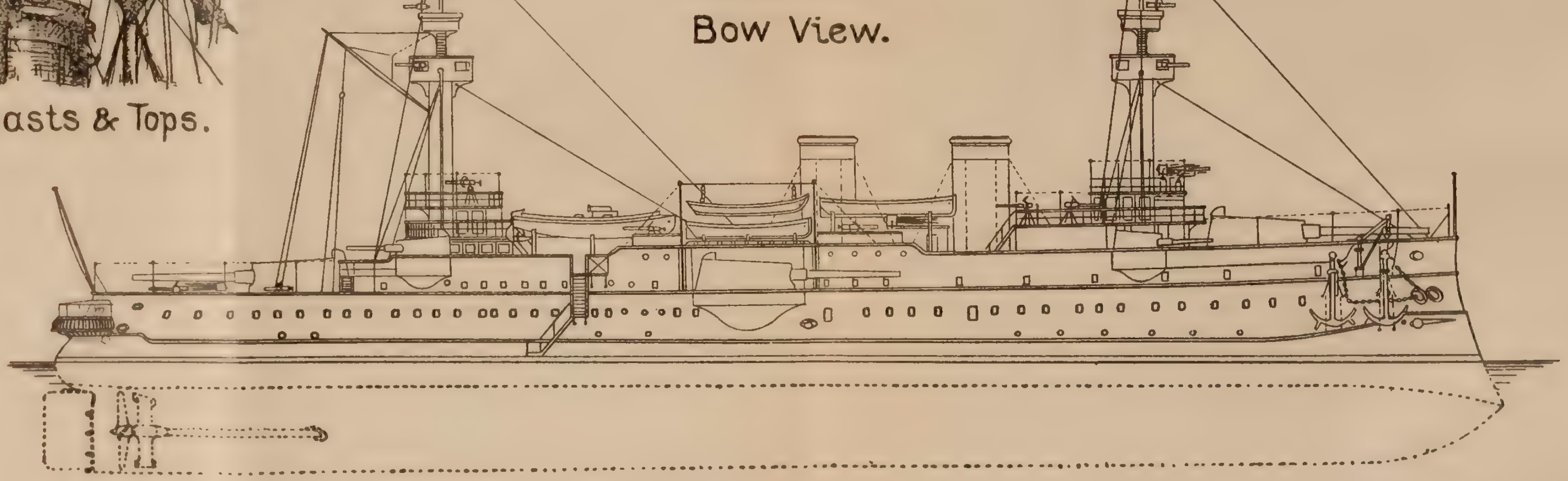
Military Masts & Tops.

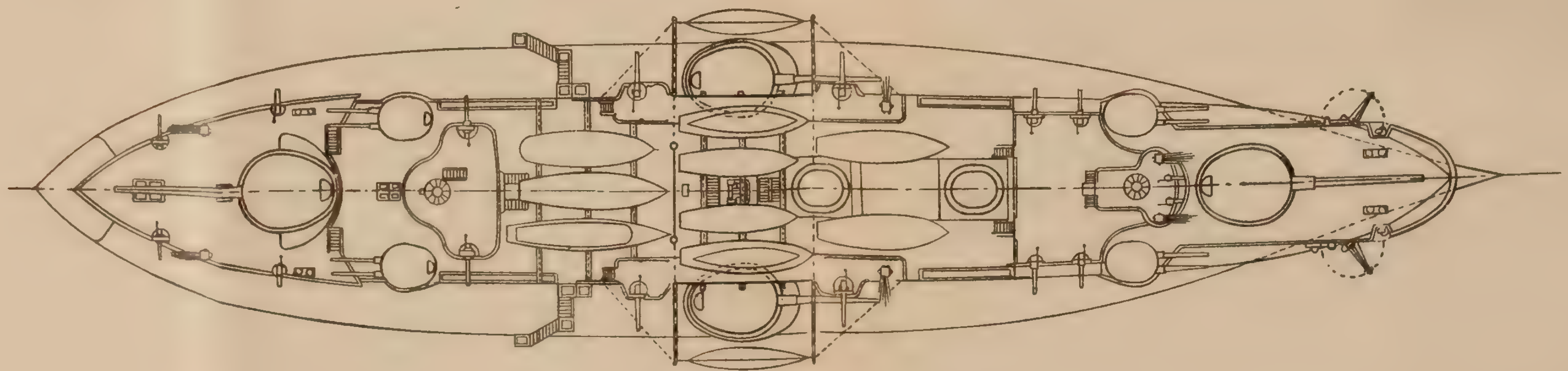


Bow View.



Midship Section.





THE JAUREGUIBERRY

Le Yacht

MASSÉNA (B)—BOUVET (A)

The contract to build the *Masséna* has been given to the Société des Chantiers de la Loire, and she is to be completed within five years.

The *Bouvet* has been recently laid down at L'Orient.

These battle-ships will be of the *Jauréguiberry* type, modified, and their *armament* will consist of two 11.8-inch B. L. in closed turrets forward and aft on centre line; two 10.6-inch B. L. in barbette turrets on each side; eight 5.5 inch R. F., four on each side, in small turrets; thirty light R. F. G., and four *submerged** torpedo tubes.

Protection.—Water-line belt of 17.7 inches maximum thickness.

Motive power.—Three engines and three propellers, which are expected to give 11,000 I. H. P. and 18 knots speed.

Dimensions.—Length, 364 feet; beam, 65.6 feet; extreme draught, 26.2 feet; displacement, 11,700 tons.

D'IBERVILLE—CASSINI.

Torpedo vessels; have been laid down by the Société de la Loire.

They are to have 925 tons displacement, about 5,000 I. H. P., and 21.5 knots speed. Their machinery is protected by a 0.6-inch steel deck.

Armament—One 3.9-inch R. F., three 9-pounder R. F., four 1-pounder R. F., and four torpedo tubes. Estimated cost, $589,800 apiece.

FOUDRE.

Torpedo depot ship, to be constructed at the Chantiers de la Gironde.

Armament.—Eight 3.9-inch R. F.. four 9-pounder R. F., four 3-pounder R. F., and five torpedo tubes.

Protection.—Steel deck 1.7 inches to 3.4 inches thick.

Motive power.—Engines of 11,400 I. H. P., to give 19 knots speed.

Dimensions.—Length, 370 feet, 8 inches; beam, 51 feet, 2 inches; mean draught, 20 feet, 2 inches; displacement, 5,970 tons.

This vessel will resemble H. M. S. *Vulcan*, being intended to carry ten torpedo boats, and being fitted with workshops and machinery for the repair of torpedoes, etc., but the hydraulic arrangements for hoisting in and out the boats differ completely from those employed on board the English ship.

She is to be ready for service by the end of 1895, and will cost about $2,186,000.

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* See Ships, Russia, *George the Conqueror*,

The new ships which it is proposed to lay down in 1893 are the following:

Prov. name.		Tons.	Indicated horse-power.	Speed, knots.	Armament.	Estimated cost.	To be built by—
Cruisers	N	7.600	13.400	19	Two 9.4-inch B. L., eight 5.5-inch, ten 3-pounder, six 1-pounder, R. F.	$3.089.000	Contract.
	O	7.600	13.400	19	....do	3,089.000	Do.
	K	3.722	9,000	19.25	Six 6.4 inch; four 3.9-inch, eight 3-pounder, twelve 1-pounder, R. F.	1,530,000	Cherbourg dockyard.
	P	3.600	9.000	19	....do	1,560,200	Contract.
	Q	3.722	9,000	19.25	....do	....	Do.
	L	2.300	6,600	20	Four 5.5-inch, two 3.9-inch, four 3-pounder, two 1-pounder, R. F., four 1-pounder, R. C.	915,000	Rochefort dockyard.
Torpedo gun-vessel, R.		925	5,000	21.5	One 3.9-inch, three 9-pounder, four 1-pounder, R. F.	560,000	Contract.
Gunboat, S		627	850	13	Two 3.9-inch, four 9-pounder, four 1-pounder, R. F.	261,400	Normand.
Sea-keeping torpedo boats.	T	......	....	23.5	Two 3-pounder, R. F.	*123,400	
	U	......	....	23.5	....do		
	V	......	....	23.5	....do		
	W	......	....	23.5	....do		
	X	......	....	24.5	....do	*151,600	
	Y	......	....	24.5	....do		
	Z	......	....	24.5	....do		
Torpedo boats	192 to 200 inclusive	80	1,300	23.5	Two 1-pounder, R. F., two torpedo tubes.		

*Apiece.

N and O are to be armored cruisers, sheathed and coppered for distant service. They will carry 650 tons of coal.

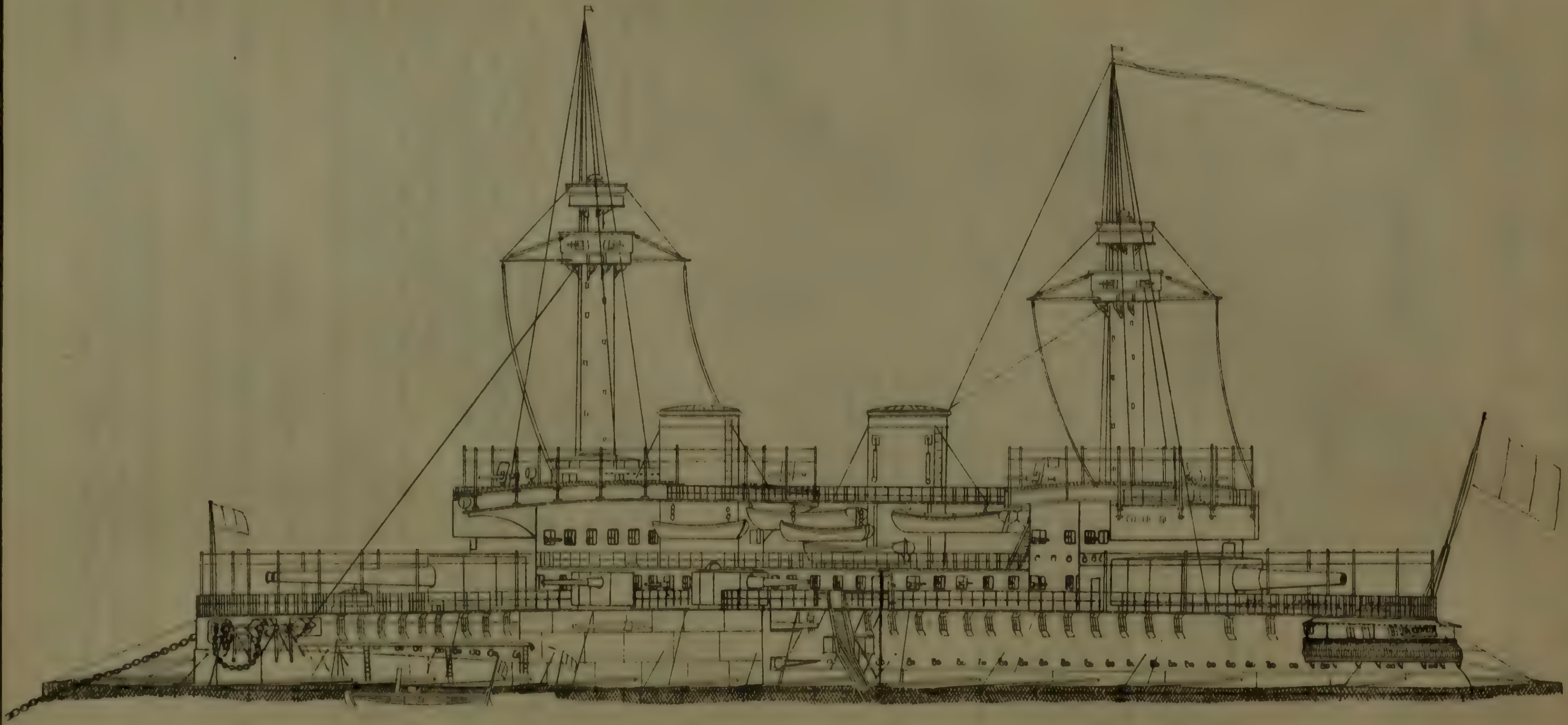
K and Q will also be sheathed and coppered, and will carry 587 tons of coal. P will carry 500 tons.

A first-class battle-ship was provided for in the original draft of this Budget, but the Minister of Marine decided to omit it; promising, however, to provide for one in time to lay the keel on January 1, 1894.

GUNBOAT FLOTILLA IN DAHOMEY.

Three small steamers, the *Topaze*, *Emeraude*, and *Corale*, have been armed and are now serving as gunboats on the lakes and rivers of this region.

A fourth boat named the *Opale* has been recently completed by Messrs. Yarrow and Co., of Poplar, and transported to Dahomey. The order for her construction was given by the French Government on April 28,



The Brennus

Le Yacht

and the vessel was launched on May 25 in a perfectly complete condition, and on the afternoon of the same day her first trial took place on the Thames.

(The French constructors demanded from 4 to 10 months to do the same work.)

This stern-wheel gunboat is 100 feet long by 18 feet beam and draws only 18 inches of water with steam up. The approximate draughts with various loads are, 24 inches with 21 tons, 30 inches with 30 tons, and 36 inches with 58 tons.

She can carry 400 troops, and the armament will consist of three 37^{mm} R. C. on the main deck and four 1-pounder R. F. on the upper deck—14 feet above the water and therefore high enough to give good range over the river banks.

On trial, six runs over the measured mile gave a trifle over 10 miles an hour, only wood fuel being used. The steaming radius is 43 miles for each ton of wood.

VESSELS LAUNCHED.

BRENNUS.

(Page 312, No. VII.)

This battle ship was launched at L'Orient on October 17, 1891. Her construction was for a long time interrupted and many plans were proposed and successively rejected before Admiral Krantz finally decided that she should be built at L'Orient.

Armament.—Three 13.4 inch B. L., two in the forward turret and one in the after turret; ten 6.3 inch B. L., six inside of a central redoubt on gun deck and four on top of the redoubt in closed revolving turrets; four 9-pounder R. F., eight 3-pounder R. F., eight 37^{mm} R. C., and five torpedo tubes.

Protection.—The turrets for heavy guns are closed and revolve on hydraulic platforms placed in the axis of the ship. They are pear-shaped and have armor 17.7 inches thick on the forward and 15.7 inches on the after one.

The small turrets are mounted on hydraulic pivots, and have steel armor 3.9 inches thick, backed by a double tier of steel plates 0.4 inch thick; total, 4.7 inches.

Steel belt, complete, from 11.8 to 17.7 inches thick amidships, and 9.8 to 11.8 inches at bow and stern.

All of these plates are backed by 19.7 inches teak at the water line.

There are two cofferdams, both filled with obturating material. The first one is under the armor belt and has for its inner wall the longitudinal bulkhead, nearest the ship's side. It extends the whole length of the ship and is divided into cells by short transverse bulkheads. The second, or upper, cofferdam is situated on the main deck, and its height above it is about 4 feet. It extends fore and aft.

The upper works are protected by armor 4.7 inches thick, 4.8 feet high forward, and 3.9 feet aft.

The protective deck is from 2.8 to 3.1 inches thick, and all openings are surrounded by armored glacis.

The battery is divided by numerous splinter screens.

A central redoubt supports four turrets, incloses two smokepipes, and forms two stages, which extend from the orlop to the spar deck. Armor 3.9 inches.

The military masts consist of chrome steel tubes about 6 feet in diameter, reaching to the lower military tops. Concentrically with the first there is another tube, 2 feet in diameter, which extends to the upper top, and is used as an ammunition-supply tube for the R. F. G.

The space between the tubes is occupied by two staircases, one for ascending and one for descending.

The conning tower is 4.7 inches, and its flooring, which forms an extension of the bridge, is 3.9 inches thick.

Motive power.—Two triple-expansion engines of 13,500 I. H. P. to give 17.5 knots.

Dimensions.—Length, 374 feet; beam at water line, not including armor, 66 feet, 10 inches; depth from spar deck, 41 feet; greatest depth, 60 feet, 8 inches; draught about 26 feet, 3 inches; displacement, 10,983 tons.

The *Brennus* will probably be ready for trial early next year and will cost about $4,760,000.

BOUVINES—JEMMAPES.

(Page 32, No. X.)

The *Bouvines* was launched by the Forges et Chantiers de la Méditerranée in March, and the *Jemmapes* by the Chantiers de la Loire in April of this year.

The four ships of this class were at first given low freeboard forward and aft, and classed as coast-defense vessels, but in the *Tréhouart* and *Bouvines* the forward gun and its turret have been raised and sufficient freeboard given to insure good seagoing qualities, and they are now classed by the French as *cuirassés-déscadre.*

The *Jemmapes* and *Valmy* remain as at first designed.

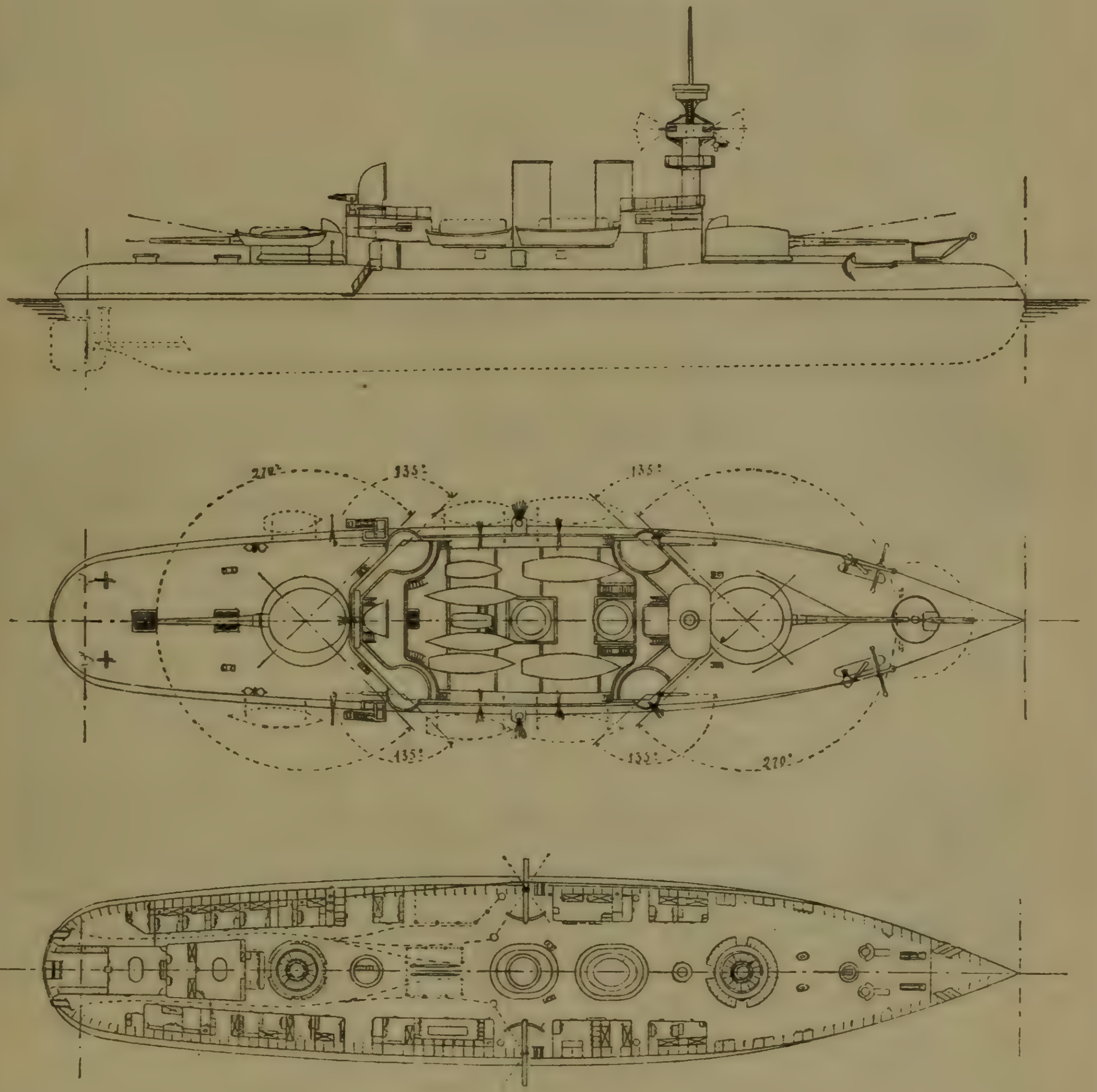
The *Bouvines* is thus described:

Armament.—Two 11.8-inch B. L. in barbette turrets on centre line forward and aft; eight 3.94-inch R. F. in broadside on spar deck; four 3-pounder R. F.; ten 37^{mm} R. C., and two torpedo tubes.

Protection.—Complete water-line belt 9.8 to 18.1 inches thick; steel deck 2.75 to 3.94 inches thick; fixed barbettes which extend to protective deck and cover the ammunition tubes, 12.5 inches thick; movable turret or cupola on top of barbette, 14.5 inches thick; gun shields, 1.5 inches steel.

COAST DEFENCE VESSELS.

JEMMAPES & VALMY.



Le Yacht.

Motive power.—Two triple-expansion engines of 8,400 I. H. P., to give about 16 knots speed with forced draft.

Dimensions.—Length, 283.8 feet; beam, 58.4 feet; depth, 22.9 feet; draught, forward, 19.7 feet; aft, 24.3 feet; displacement, 6,590 tons.

Cost.—Hull, $2,143,853; machinery, $390,000; guns and torpedoes, $252,600; contingencies, $130,000; total, $2,916,453.

STYX.

(Page 33, No. X.)

Armored gun vessel, launched at Cherbourg in August, 1891.

The secondary batteries of these ships are to consist of two 3-pounder and five 1-pounder R. F. G. Their estimated H. P. is 1,700 and speed 13 knots.

LÉGER.

(Page 28, No. IX.)

Torpedo vessel, launched at L'Orient, August 4, 1891.

STEAM TRIALS.

PERFORMANCES OF THE MEDITERRANEAN RESERVE AND CHANNEL SQUADRONS.

The official trials of the vessels composing the Mediterranean Reserve Squadron took place early in May of this year, when it appeared that the *Colbert*, *Redoubtable*, *Richelieu*, and *Friedland* had lost almost a knot of their original speed, and some trouble was found in reversing the engines of the last-named ship.

The trials of the *Caïman* were brought to an end by the heating of a piston rod, and great trouble was also found with the torpedo vessel *Bombe*, which returned to harbor with damaged engines.

The *Marceau* and *Hoche* had defective boiler tubes.

During the first cruise of the new channel squadron (Escadre du Nord) the run from Brest to Cherbourg was made in twenty-six hours.

The wind was somewhat fresh from the northeast, and a moderate sea washed over the forecastles of the coast-defense vessels *Tonnerre* and *Fulminante*, making it evident that in rough weather they would have found it difficult to keep up with the rest of the fleet.

NEPTUNE.

(Page 28, No. IX.)

Trials of this battle ship, which took place in November, 1891, gave a mean speed of 15.7 knots on the measured course, but it was found necessary to repair the machinery on account of the scoring of slide valves.

A forced-draft trial on June 18 was more satisfactory, as a speed of 16.02 knots was obtained with 11,045 I. H. P. and 87.6 revolutions.

ADMIRAL DUPERRÉ.

Recent trials of this battle ship (11,000 tons) have proved quite successful, as a speed of 14.1 knots was obtained with 7,400 I. H. P., practically the same as that obtained on her first trials in 1882.

SUFFREN.

A battle ship of 7,800 tons displacement, built in 1870; had trials last April, which were not altogether satisfactory.

An attempt to run six hours, at full speed, was interrupted by the heating of a piston rod; and although she finally succeeded in completing it, the speed obtained was only about 13 knots. An attempt to run for twenty-hours in the open sea was interrupted by an accident to one of the condensers.

PHLÉGÉTON.

(Page 33, No. X.)

The trials of this armored gun vessel have given a speed of 13 knots.

JEAN BART—ALGER.

(Page 28, No. IX.)

Trials of these protected cruisers have given the following results:

Jean Bart.—November, 1891: Total I. H. P., 7,846; speed, 18.65 knots with 116.2 revolutions; engines worked very well; vibration not sensible; combustion and ventilation good.

Alger.—November 21, 1891: Speed, 12 knots with 72 revolutions; 12 boilers in use.

November 27: Speed, 17 knots with 101 revolutions; 18 boilers.

December: Speed, 18.8 knots with 7,800 I. H. P.; 24 boilers.

March 9, 1892: Speed, 12.6 knots during six hours, with 2,000 I. H. P. and 73 revolutions; 9 boilers.

March 18 and 19: Speed, 17.3 knots during 24 hours, with 5,000 I. H. P. and 101 revolutions; 18 boilers.

April 29: Speed, 19.5 knots during four hours; 21 boilers.

May 10: Speed, 19.61 knots; 24 boilers; coal consumption per hour and per I. H. P., 1.6 pounds; I. H. P., 8,200; revolutions, 116.

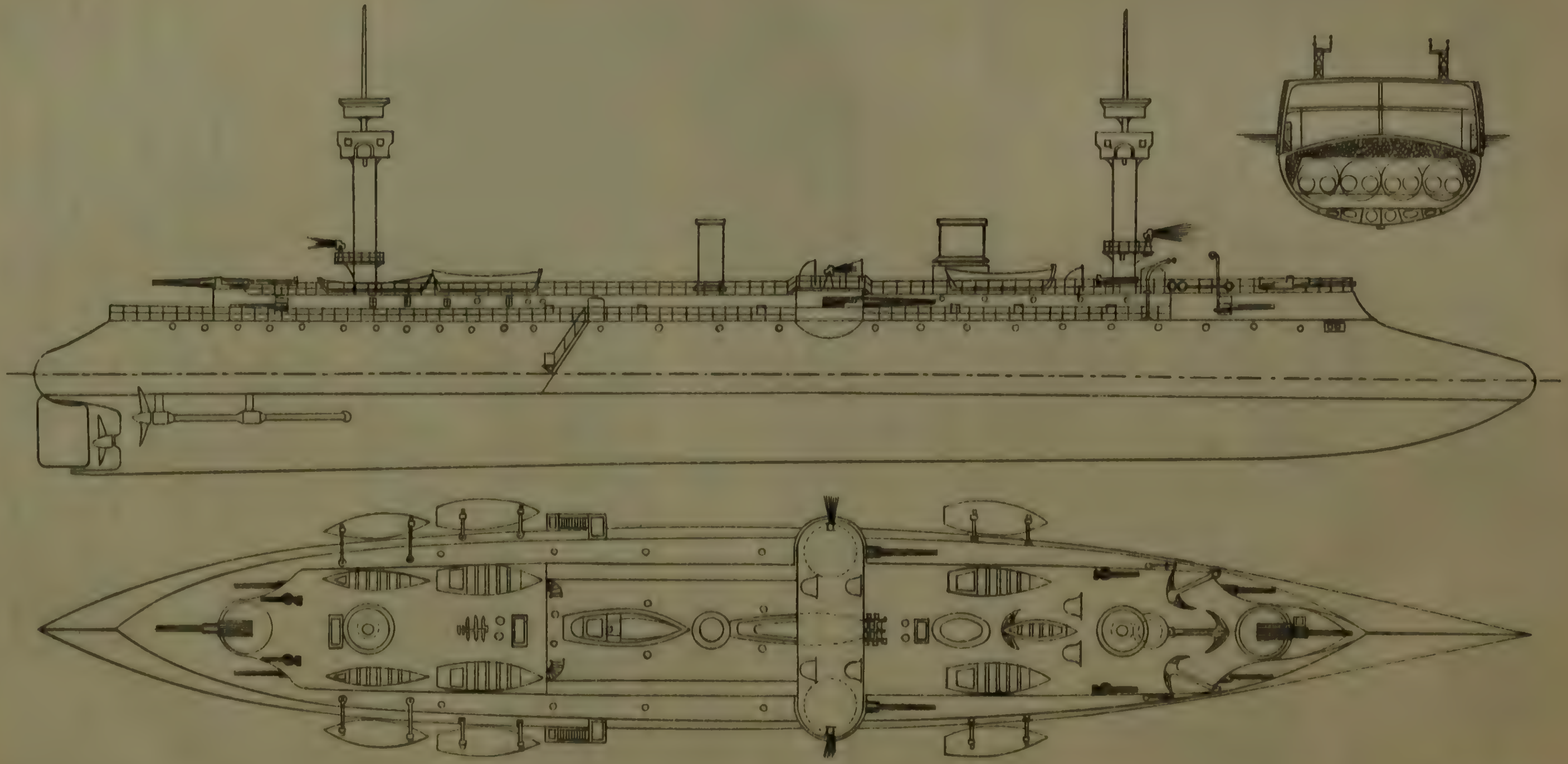
DAVOUT.

(Page 38, No. X.)

A trial in November, 1891, gave a speed of over 19 knots, but in spite of various alterations the heat in her fire rooms was so great that the men could hardly remain at their posts.

Another run on May 12, 1892, was more satisfactory, as the cruiser developed 8,200 H. P. and obtained a mean speed of 19.79 knots in the open sea, and her official trials which terminated on June 12 gave still better results, viz: 20.75 knots with 132 revolutions and 8,880 I. H. P.

DUPUY DE LÔME



Le Yacht

COSMAO—COËTLOGON.

(Pages 29, No. IX, and 38, No. X.)

The *Cosmao* terminated her trials on July 10, 1891, in a most satisfactory manner. The contract only required 19.5 knots, and as this speed could be easily obtained the contractors did not run the engines at full power. The revolutions were kept down to 133 per minute, but notwithstanding this limitation a mean speed of 20.603 knots was obtained.

The *Coëtlogon* finished another series of trials on December 1, 1891, and was then reported as having been finally accepted, but an examination of her machinery last January, by a committee appointed for that purpose, disclosed the fact that two of her cylinders were cracked, and they are said to have advised the Minister to definitely refuse to accept the machinery.

The last run at Brest gave a mean of 19.37 knots during six hours. It was her twenty-ninth trial.

LÉGER—LÉVRIER.

Torpedo vessels of 450 tons displacement (page 34, No. X) have had preliminery trials, with good results.

During their first runs, some months ago, when making 14 knots with 240 revolutions, the vibrations of their hulls were so severe that it was necessary to stop the trials and make certain modifications.

On May 12 the *Lévrier* made 305 to 310 revolutions without vibration, and obtained a speed of 18 knots.

The *Léger* obtained 18.5 knots, with 2,345 I. H. P.

WATTIGNIES.

Third-class protected cruiser (page 33, No. X) has made 18.5 knots with 4,200 I. H. P.

DUPUY DE LÔME.

The trials of this armored cruiser have been looked for with great interest, as she is the first ship of her class to be fitted with three propellers.

Her three engines are entirely independent of each other, the two side ones being of the horizontal type and the middle one vertical.

During her dock trials in January, 1892, the machinery worked in a most satisfactory manner, and a preliminary run in June gave a speed of 16 knots, with 90 revolutions, but her first full power trial was interrupted by a serious accident.

The engines were working up to a speed of 110 revolutions, and all was going well, when a leak suddenly occurred in the crown sheet of the middle boiler in forward fireroom. Hot water and steam rushing through caused a back-draft and a burst of flame into the fireroom.

Other leaks are said to have occurred at the same time in the auxiliary boilers, and before the fireroom doors could be opened, sixteen men were severely injured.

The authorities are now making a thorough investigation of this unfortunate occurrence, and it will be some time before the engine trials can be renewed.

As the description of this cruiser on page 312, No. VII, is not complete the following additional notes are given:

The two 7.5-inch B. L. are carried in closed turrets 4 inches thick, on beam sponsons; two of the 6.3-inch B. L. are on high barbettes, in center line forward and aft, the other four being in casemates below them on main deck level.

The complete side protection has a total thickness of 4.7 inches and extends from 4 feet, 7 inches below the water-line to the upper rail, 8 to 13 feet above it.

The steel protective deck is 1.5 inches thick.

VESSELS LOST OR STRUCK FROM THE LIST.

Albatross, paddle-wheel gunboat, lost near the Gaboon River, coast of Africa, November 12, 1891.

Volage, gunboat, wrecked in the Society Islands, August, 1891.

Intrépide, transport, sold in 1891.

Infernet, unprotected cruiser, condemned in 1891; to be sold or broken up.

Boursaint, dispatch vessel, condemned in 1892.

Seignelay, unprotected cruiser, condemned in 1892.

Provence, armor-clad; to be sold or broken up.

Chacul, gun vessel; to be sold or broken up.

Pique, gun vessel; to be sold or broken up.

Lamothe-Piquet, dispatch vessel; to be sold or broken up.

Ouessant, brig; to be sold or broken up.

Carpe, gun launch; to be sold or broken up.

Marne, transport; to be sold or broken up.

Étendard, gunboat, condemned in 1892.

Vigelant, dispatch vessel, condemned in 1892.

Européen, transport, condemned in 1892.

Chamois, gunboat, condemned in 1891; to be sold or broken up.

Gogah, paddle dispatch boat, condemned in 1892; to be sold or broken up.

Bécassine, *garde-pêche*, condemned in 1892; to be sold or broken up.

Bergeronnette, *garde-pêche*, condemned in 1892; converted into a hulk.

Pacifique, transport, construction abandoned.

Dordogne, hospital hulk, condemned in 1892.

Perle, schooner, condemned in 1892.

Tigre, coast-defense vessel, condemned in 1892.

Fonténoy, frigate, condemned in 1892.

Favorite, corvette, condemned in 1892.

Barbillon, *garde-pêche*, condemned in 1892.
Oyapock, dispatch vessel, to be sold.
Aoraï, schooner, condemned in 1892.
Volta, cruiser, condemned in 1892.
Châteaurenault, cruiser, condemned in 1892.
Courlis, gun launch, condemned in 1892.
Alcyone, gun launch, condemned in 1892.
Francis Garnier, gun launch, wrecked in May, 1892.

The armor-clad *Héroine* and the transport *Corrèze* have been turned into hulks.

The *Actif* has been condemned as a gunboat and converted into a tugboat.

TORPEDO BOATS.

The question as to whether search lights should be carried by torpedo boats, or not, has been under discussion since last November, and after obtaining the opinions of many officers on the subject the authorities finally decided, in March, 1892—

(1) That electric search lights should be retained on *torpilleurs-de-haute-mer* (100 tons and upwards) which may be required to perform the duties of torpedo boat catchers and scouts, as well as those of ordinary torpedo boats. These projectors to have at least 15.7 inches diameter and be placed, if possible, where their light will not embarrass the commanding officer and where they will be sheltered from the spray.

(2) That electric search lights shall be done away with on all first, second, and third class torpedo boats.

It was also decided that all torpedo boats should be provided with a bell in order to prevent their being run down in thick weather.

CORSAIRE—CHEVALIER—MOUSQUETAIRE—LANSQUENET—FILIBUSTIER—ARIEL—TOURMENTE.

These seven names have been added to the list of *torpilleurs-de-haute-mer* (page 39, No. X).

The *Corsaire* has been constructed at St. Denis by the Société des Chantiers de la Loire, the *Chevalier* by M. Normand, at Havre, and the *Mousquetaire* by the Société des Chantiers de la Méditerranée.

The *Lansquenet* has been recently laid down by M. Oriolle at Nantes, and it is reported that she is to be 164 feet long and have 26 knots speed. The last three boats will be commenced during the coming year.

The following description of the *Mousquetaire* has been published: Length, 154 feet; beam, 15.4 feet; extreme draught, 6.2 feet; displacement when fully loaded, 125 tons.

Armament.—Two 18-inch torpedo tubes on deck and two 1-pounder R. F. G.

Motive power.—Two three-cylinder compound engines, having cylinders of 15.8 inches, 23.6 inches, and 35.5 inches diameter, with 15.8 inches stroke. The two Thornycroft boilers are among the largest of that type yet constructed, having a grate surface of 41.2 square feet and weighing complete, with water, about 16 tons each. The engines and boilers are so arranged that either boiler supplies steam to either engine (both systems being kept entirely separate, if necessary), or one boiler can supply both engines. This machinery is expected to develop 2,100 I. H. P. and give 24.5 knots speed.

STEAM TRIALS.

ÉCLAIR—ORAGE—KABYLE.

These first-class boats, which were ordered in June, 1890, have been constructed by the Forges et Chantiers de la Méditerranée, at La Seyne.

They are 143 feet long by 15 feet beam and displace 106 tons. Their armament consists of two launching tubes, one fixed in the bow and one on a turntable aft, which trains through an arc of 260°. Two 1-pounder R. F. G. are also carried, and one search light.

Triple-expansion engines are supplied by two Thornycroft boilers.

The trials of the *Éclair* took place in October, 1891, under the following conditions: The boat was fully loaded, having on board her complete armament, torpedoes, ammunition, crew, and a supply of coal sufficient to carry her 1,650 miles at 10 knots.

The full-speed trial was made in unfavorable weather, but the mean speed during one hour was 21.5 knots with 317 revolutions.

During the remaining five hours the mean speed was 18.46 knots with 271 revolutions and 29.7 pounds boiler pressure.

When returning to port heavy weather was encountered, but, although the *Éclair* rolled considerably she showed no lack of stability and proved to be an excellent sea-boat.

A speed of 15 knots was maintained with no injury to engines or boilers.

The trials of the *Orage* in January, 1892, gave a maximum speed of 21.7 knots with 315 revolutions.

The *Kabyle* obtained 21.6 knots with 317 revolutions.

ALARME. (148 tons.)

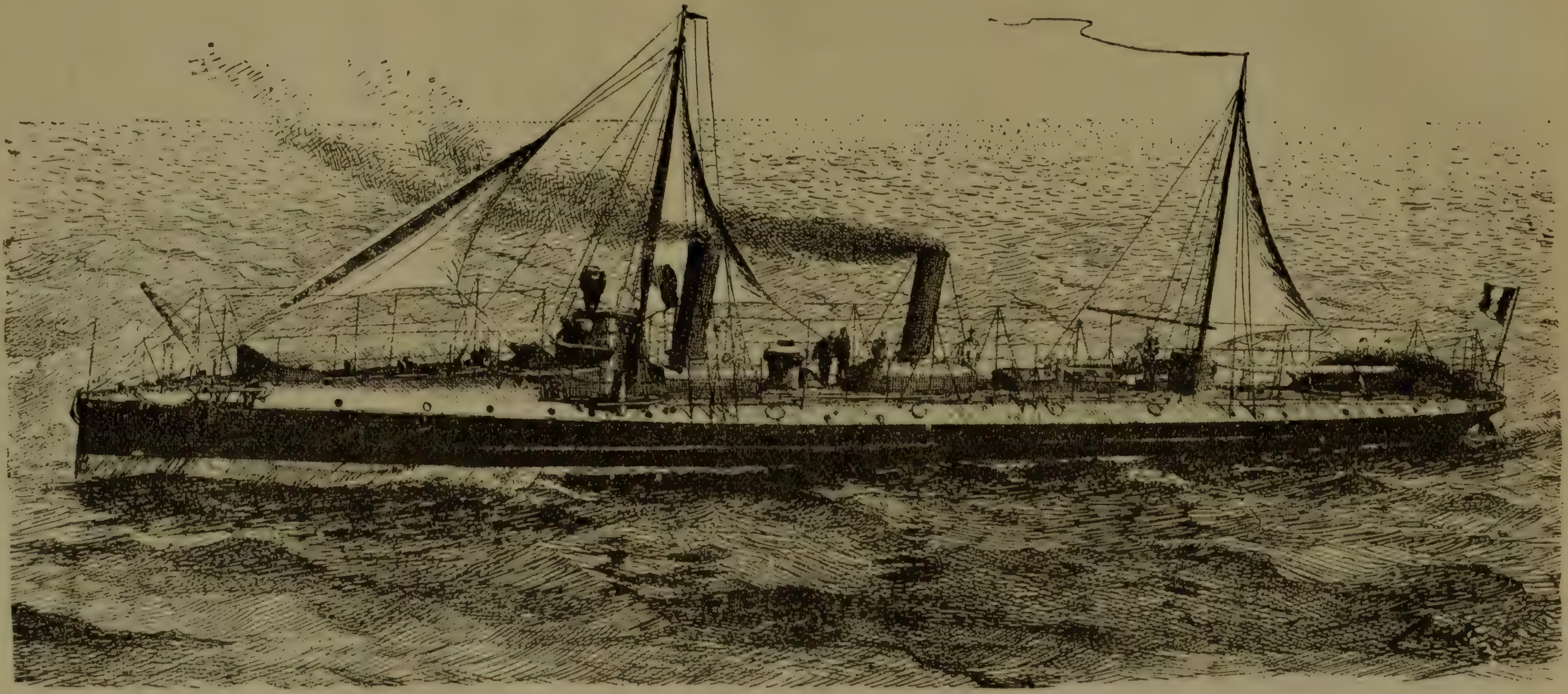
(Page 443, No. VIII.)

A trial on December 19, 1891, gave a mean speed of 20.3 knots.

VÉLOCE—GRONDEUR. (114 tons.)

(Page 37, No. X.)

These boats are similar to the *Coureur*, which Messrs. Thornycroft built for the French in 1888, and which gave such excellent results



THE ECLAIR

Le Yacht

both on trial and in actual service. Their hulls have been constructed in a French establishment on plans furnished by Mr. Thornycroft, who built and fitted the engines and boilers himself. According to the terms of the contract, the speed during four hours should have been 23.5 knots.

The *Véloce* did slightly better than this during the first three hours of her trial, but was obliged to slow down during the last hour, on account of the heating of a piece of machinery, and the average speed obtained during the whole run was therefore only 22.78 knots. This required a penalty of 2,000 francs from the English firm in addition to 10,000 francs already paid for excessive coal consumption.

Some French authorities consider that the hulls of these boats are too lightly built and the disposition of their armament bad, the system of two parallel bow tubes being condemned and no longer followed by the latest practice.

ZOUAVE—TURCO, (120 tons.)

The official trials of the *Zouave* took place at Brest on May 5, and proved very satisfactory.

The contract required a run of five hours at the rate of 18.5 knots, and one hour at 20.5 knots.

Both of these conditions were exceeded, as the boat attained 21.3 knots with 307 revolutions. Everything worked well, and a greater speed could have been obtained if required.

The *Turco* has also been successful and is now in commission.

These boats have cost $113,050 apiece.

Nos. 147, 148, AND 149. (80 tons.)

These Normand boats have been remarkably successful.

No. 147 was given two trials; the first, which was intended to determine the quantity of fuel required to steam 1,800 nautical miles at a speed of 10 knots, took place in November last, and gave for a result 9.93 tons. This amount of coal was carried on her speed trials when 23.684 knots were obtained during a two-hour run with 329.3 revolutions.

Her boilers, which are of the Temple type, gave a good supply of steam.

No. 148 had trials last March, when she made 23.4 knots during two hours and 23.92 on the measured course.

These good results are said to be due in a great measure to certain modifications to the propellers that have been introduced by M. Normand. The three blades have been made wider, and as the change has done away with all slip, the authorities now think of applying the same principles to the screws of large war ships.

The boilers of *No. 149*, like those of *No. 148*, are of a new type invented by M. Normand, and she is also supplied with certain new auxiliary arrangements which seem to have given satisfaction. The most important of these is an apparatus which increases the temperature of the feed water from 90° to 116° when running at full power. This device has been found to decrease the coal consumption from 15.1 to 12 pounds per mile at 10 knots speed, but it will not be finally adopted until more thorough tests have been made in the next boat of the class.

The official full power trial of *No. 149* took place last May at Cherbourg, and gave better results than have ever yet been obtained under the same conditions.

The following table gives the most important details:

	Revolutions.	Speed.	Temperature of feed water.	Air pressure.	Remarks.
		Knots.		*Inches.*	
Mean of three runs on the measured course	325. 95	23. 585	114	2. 4	Displacement in tons, 76.453. Armament on board, and 9.86 tons coal.
Two-hour run in the open sea	339. 17	24. 510	116	2. 5	
Mean of three runs on the measured course	341. 4	24. 642	117	2. 4	

SUBMARINE TORPEDO BOATS.

The following extracts from an official statement of the Minister of Marine show that the *Gymnote* has been quite successful, and that he expects better things of her successor, the *Gustave Zédé**; the *Goubet*, on the other hand, failed to carry out a programme laid down by her inventor, and can not, therefore, be counted upon as an efficient weapon for war purposes:

> I do not think that any country in the world is so far advanced as ours in the construction of submarine torpedo boats. Although the *Gymnote* is but an experimental craft, not intended to discharge torpedoes, her designer, M. Zédé, is the only person who, to my knowledge, has solved in a satisfactory manner the problem of submarine navigation, that is to say, the running of a direct course under water toward any determined point.
>
> This was proved last year at Toulon, when the *Gymnote* ran outside of the harbor and directed her course under water towards the *Couronne*, without deviating from the straight line for a moment.
>
> It is not sufficient, however, to have built an experimental boat; it remains to make her useful by giving her weapons to fight with, thus adapting her to war purposes. It is towards this end that all our efforts are directed, and, without entering into details, I can inform the Chamber that in 1892 we will have a submarine torpedo-boat, named the *Gustave Zédé*, which, if we are not mistaken, will give results not yet attained by any other naval power.
>
> In speaking of the *Goubet* I am obliged to inform the Chamber that success has not completely crowned the efforts of her constructor.
>
> I have complied with all his conditions, and when he was ready for trial I appointed a Commission (Trial Board) of naval officers, whose reputations gave every guarantee of impartiality.

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* The cost of this boat as officially estimated will be $223,800, divided as follows: hull, $101,800; machinery, $112,000; armament, $10,000.

The last trials took place in May and June, 1891, and Admiral Gervais reports as follows concerning them:

"On May 19 the little boat went out of port, accompanied by certain members of the Commission, who followed her in a steam launch:

While on the surface the *Goubet* appeared to run and manœuvre with sufficient facility. Arriving near the *Marengo* the order was given to descend to a depth of two metres and continue the direct course. This order was not executed. During the first fruitless attempt the boat remained out of sight for some time and then reappeared in an entirely different direction from that expected, rendering it impossible for the Commission to keep track of her very uncertain movements under water. A second attempt was interrupted by the breaking of one of the leveling pipes, which rendered it necessary for the crew to detach the safety-weight and return to the surface." * * *

"In continuation of my letter of May 26, 1891, I have the honor to report that the Commission reconvened on June 19, at the request of M. Goubet to examine whether his boat was capable of executing a programme submitted by himself. This programme was not successfully carried out, and the Commission, after giving a detailed report, came to the conclusion 'that these trials throw no light on the ability of the boat to steer a direct course under water, and that in this respect all remains to be proved.'"

The Minister of Marine then continues:

As far as I am concerned I consider that for the present M. Goubet has demonstrated:

(1) That the habitability of his boat is assured.

(2) That the voluntary immersion of the boat, when stationary, to any required depth is a point gained.

(3) That when running at the surface she is entirely under the control of her crew and can be manœuvred at a speed of from 3 to 4 knots.

But I must here add that up to the present time the boat has never been able to navigate under water, before the Commission, and that whenever this part of the programme was reached the manœuvres became very uncertain. Consequently I agree with the Commission that the ability of the *Goubet* to navigate under water and be used as a submarine torpedo boat remains to be proved.

The report of the Commission was indorsed by M. Goubet as correct.*

ITALY.

The Naval Estimates for the financial year, which commences July 1, 1892, amounted to about $20,000,000, of which $5,000,000 is available for new construction.

Work is to continue on the battle ships *Re Umberto*, *Sicilia*, and *Sardegna*, the protected cruisers *Etruria*, *Umbria*, *Liguria*, *Marco Polo*, *Elba*, *Lombardia*, and *Calabria* (F), the unprotected cruiser *Governolo* (J), the torpedo vessels *Tersichore* (I), *Clio* (K) and L, and a number of first-class torpedo boats.

The *Calabria* has been laid down at Spezia, but work on her seems to have been temporarily suspended. She is of the *Lombardia* type and has 2,467 tons displacement.

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* The above official report concerning the *Goubet,* like that on the Spanish boat *Peral* (page 52, No. X), shows that the newspaper descriptions of their performances (pages 33 and 43, No. IX) give a very exaggerated idea of their value as engines of war.

The *Clio*, building at the Orlando establishment, may be considered an improved *Partenope*. Their dimensions are nearly identical, but the *Clio* is to have a top-gallant forecastle, which will make her a better seaboat.

A new programme of construction has been under consideration by the Superior Council for some time, and it is now (May, 1892) reported that they have adopted three new types of war vessels.

The first typical vessel is a battle ship of 15,000 tons displacement, completely armored, and carrying six 56-ton B. L., and a large secondary battery.

The second type is an armored cruiser of 7,500 tons, with six 56-ton guns, and the third an armored cruiser of 6,700 tons, and four 56-ton guns.

These heavy weights are probably carried at the expense of coal capacity, it being naturally the policy of Italy to build ships principally for service in the Mediterranean.

The battle ships will have a speed of 19 knots, and the cruisers 21 knots.

Four cruisers, two of each type, have already been ordered, and the battle ship will be commenced during the current financial year.

VESSELS LAUNCHED.

SICILIA.

Battle ship of 13,300 tons displacement, was launched at Venice, on July 6, 1891.

She is similar to the *Sardegna*, described on page 42, No. X.

URANIA—IRIDE—MINERVA.

Torpedo vessels of *Partenope* type (page 343, No. VIII), were launched in June and July, 1891, and February, 1892. (See Steam Trials.)

ERCOLE (H)—ATLANTE (G).

Armed seagoing tugs and supply vessels (page 42, No. X), were launched in February and May of this year.

The *Atlante* has made 13 knots on trial and given general satisfaction.

She is fitted with steel hawsers for towing, and has a powerful pump with a capacity of 500 tons of water per hour.

The battery consists of two 6-pounder and two 1-pounder R. F. G.

STEAM TRIALS.

URANIA—IRIDE.

The first of these torpedo vessels is reported as being successful. A trial in August, 1891, gave a mean speed of 19.6 knots, while one in

December gave 20 knots during six hours with forced draft, and 16 knots for twenty-four hours with natural draft.

The *Iride* has had a preliminary trial that developed some defects in her boilers. No details of later trials have been received.

SAN MARTINO.

Armored cruiser (4,234 tons), has been given comparative trials with coal and petroleum fuel. With the former she could only steam at a speed of 9 knots, whereas with the liquid combustible she attained 13 knots an hour.

The *San Martino* and her sister ships *Ancona*, *Castelfidardo*, and *Maria Pia*, are broadside armor-clads, built in 1864–'66.

They have all been remodeled and converted into quite effective war vessels, having military masts, modern engines, and batteries of rapid-fire guns.

TORPEDO BOATS.

According to an official order, dated July 18, 1891, the following numbers are assigned to twelve new boats of the Schichau type: *105 S*, *136 S*, *137 S*, and *138 S*, given by contract to the house of N. Odero, on June 23, 1891. *139 S*, *140 S*, *141 S*, *142 S*, *143 S*, and *144 S*, given to G. Ansaldo & Co., on July 2, 1891; *145 S* and *146 S*, given to E. Cravero & Co., on July 4, 1891.

No. *105 S* has been thus described: Length, 128 feet; beam, 15 feet 9 inches; extreme draught, 6 feet 6 inches; displacement, 79 tons; I. H. P., 1,000; coal supply, 17 tons; armament, two 37^{mm} R. F., and two torpedo tubes. Estimated cost, $60,500.

Two torpedo boats of the *White* type were ordered on October 12, 1891. They are to be known as *XIII* and *XIV*.

Six seagoing boats were contracted for in June, 1892.

SUBMARINE BOATS.

Naval Constructor Pullini, of the Italian Navy, is the inventor of a submarine boat, which has recently been launched at the Spezia Dockyard.

She is said to have about 100 tons displacement. There are five screws, two for propelling the boat and three to regulate her submersion.

Successful trials are reported to have recently taken place. Four men remained at a depth of from three to four metres under water for five hours without the least inconvenience.

Another submarine boat, named the *Audace*, was launched on March 24, 1892, at the works of Migliardi Brothers, of Savona. She is not intended for war purposes.

RUSSIA.

VESSELS PROPOSED OR LAID DOWN.

The total amount granted for all naval purposes during 1892 was $38,309,584, and the following new ships were provided for:

Name of ship.	Type.	Where to be built.	Estimate for 1892.	Estimated total cost.
Sisoï Veliki	Armor-clad of Ghangoot type, 8,800 tons.	New Admiralty Works, St. Petersburg.	$1,140.000	$4,281,000
Petropavlovsk	Armor-clad of Navarino type, 10,960 tons.	Galernaia Island, St. Petersburg.	840,000	5,906,400
Voevada	Torpedo vessel, Kazarski type.	Schichau's Works, Elbing.	300,000	600,000
Pocadnick	do	do		
Griden	do	Nicolaieff	120,000	360,000
(?)	Ten torpedo boats	1 in France by Normand	462,000	120,000
		9 in St. Petersburg		*78.000
(?)	Coast-defense vessel to follow Gremiastchy.	Admiralty Works	408,000	2,250,000
(?)	Coast-defense vessel to follow Otvagenii.	do	390,000	2,220,000
(?)	Torpedo vessel	Abroad	600,000	1,080,000
(?)	do	do		720,000
Poltava	Armor-clad of Navarino type, 10,960 tons.	Admiralty Works	900,000	5,906,400
(?)	Armored cruiser, Rurik type, 11,000 tons.	Baltic Works	360,000	4,636,500
Sevastopol	Armor-clad of Navarino type, 10,960 tons.	Galernaia Island	480,000	5,906,400

* Apiece.

A law published in February of this year has granted the Russian Volunteer Squadron (page 45, No. X) an annual subsidy of $360,000 for a period of ten years, on condition that during that time four swift cruisers, each having a displacement of not less than 8,000 tons, and two transports especially adapted to commercial purposes, shall be added to the fleet.

Ten steamers are now in course of construction or about to be ordered in France and England. They are to be named after the following Russian provinces: *Toula*, *Riazan*, *Tambov*, *Voronej*, *Koursk*, *Pensa Sirubirsk*, *Kazan*, *Viatka*, and *Orenburg*.

A 10,000-ton auxiliary cruiser and convict ship was ordered in May, of Hawthorne, Leslie & Co. She has been named the *Kieff*.

A small steamer named the *Yakoute* has been purchased in England and sent to Siberia for service as an armed transport.

TRI-SVIATITELIA. (THREE SAINTS.)

The 12,400-ton battle ship (page 44, No. X) which was laid down last year, at Nicolaieff, has been given the above name.

SISOÏ VELIKI.

This battle ship, now in course of construction at St. Petersburg, has been thus described:

Armament.—Four 12-inch B. L. in two barbette turrets; six 6-inch B. L. in casemate on upper deck; twelve 3-pounders and four 1 pounder H. R. F., and two Baranoffski guns.

Motive power.—Engines of 8,500 H. P. to give 16 knots speed.

Dimensions.—Length 352 feet; beam 68 feet; displacement 8,880 tons.

MORIAK.

A steel corvette destined as a schoolship for naval cadets, was laid down in January of this year at the Nevski works. She will have the following dimensions; length 180 feet, beam 34 feet, mean draught 13 feet, displacement 1,045 tons.

SILATSCH.

A transport said to have been laid down by the Moscow Company in October 1891.

VESSELS LAUNCHED.

NAVARINO.

(Page 38, No. IX.)

Battle ship; launched at St. Petersburg on October 20, 1891.

Armament.—Four 12-inch B. L. in closed turrets, forward and aft; eight 6-inch B. L. in a central casemate; eight 3-pounder H. R. F.; four 37^{mm} H. R. C; two Baranoffski R. F., and six torpedo tubes.

Protection.—A partial water-line belt, 14 to 16 inches thick, is terminated by 12-inch traverses; side armor above this belt is 12 inches thick, and on sides of superstructure 5 inches. The turrets are 12 inches thick, and protective deck 2½ to 3 inches.

Motive power.—Triple expansion engines of 9,000 H. P., to give 16 knots speed.

Dimensions.—Length, 338 feet; beam, 67 feet; draft, 25 feet; displacement, 9,476 tons.

Cost.—Hull and machinery, $3,864,966; armament, $804,000; electric lighting, $177,300; total, $4,846,266.

GEORGEI POBIEDONOSETS (GEORGE THE CONQUEROR).

(Page 44, No. X.)

Battle ship; launched at Sebastopol March 9, 1892.

Armament.—Six 12-inch 52-ton B. L. in three barbettes; seven 6-inch B. L. in central battery; eight 3-inch Baranoffski R. F., six 1-pounder R. F., and seven *submerged* torpedo tubes. (This last is a notable point, as no other battle ship has yet been fitted in this manner, and it shows the tendency toward making the defense against rapid-fire guns as complete as possible.)

Protection.—Steel armor for the water-line belt, barbettes, and casemates was obtained from the Creusot Works. The thickness of the plates varies from 7.87 to 15.75 inches.

Motive power.—Engines of 16,000 H. P., to give 17.5 knots speed.

Dimensions.—Length, 339 feet, 6 inches; beam, 69 feet; displacement at normal draught of 26 feet, 7 inches, 10,280 tons.

GREMIASTCHI—OTVAGENII.

(Page 44, No. X.)

Armored gun vessels launched May 19, 1892.

SARATOV.

Armed transport for the Volunteer Fleet was launched by Messrs. Hawthorne, Leslie & Co., at Hepburn-on-Tyne, July 23, 1891.

Her two sets of triple-expansion engines are expected to give 10,000 I. H. P. and 18 knots speed, and she will carry a battery of 6-inch guns.

BUG—DUNAI.

Mine and torpedo transport steamers (page 44, No. X) were launched at the Motala Works, Sweden, in the autumn of 1891.

Their dimensions are: Length, 203 feet, 4 inches; beam, 32 feet, 8 inches; draught, 14 feet, 9 inches; displacement, 1,360 tons.

Engines of 2,800 I. H. P. are expected to give a sea speed of 13 knots.

The *Bug* is said to have made 14.75 knots on trials.

VESSELS LOST OR STRUCK FROM THE LIST.

Jemchug, dispatch boat, condemned; to be sold.
Polarnia-Svezda, convict transport, condemned; to be sold.
Olaf, convict transport, condemned; to be sold.
Rurik, frigate, condemned; to be sold.
Svetlana, unprotected cruiser, condemned; to be sold.
Zabava, tank vessel, condemned; to be sold.
Variaghe, corvette, condemned; to be sold.
Griden, frigate, condemned; to be sold.

TORPEDO BOATS.

As noted above, the Estimates for 1892 provide for ten new boats, one to be built by M. Normand, at Havre, and nine at St. Petersburg.

The following is a list of boats which have been recently laid down or completed:

Name.	Displacement.	Where built.
	Tons.	
Ekness	81	Creighton's yard, Abo.
Borgo	81	
Bjorke	81	Putiloff works, St. Petersburg.
Rochensalm	81	
Haysal	81	
Moonsund	81	
Dago		Abo.
Katka		
Kronschlot		Sjora works, Kolpiro.
Seskar		
Anapa	81	Odessa.
Aitodor	81	
Itzvar	81	

ELECTRIC LAUNCHES.

Three of these boats have been recently constructed by an English firm for the Russian Government; one to be used for harbor work and two as picket boats for seagoing ironclads.

STEAM TRIALS.

AITODOR—ANAPA.

Preliminary trials of these boats have been very unsatisfactory, as the best speed obtained was only 18 knots. New propellers are to be fitted and better results are then hoped for.

GERMANY.

The total Naval Votes for the year 1892–'93 amount to $25,611,000.

The following sums will be expended upon the construction of new war vessels. (See building programme, page 354, No. VIII.)

BATTLE SHIPS A, B, C, D.

Brandenburg (A), fourth and last payment, $799,200.
Battle ship B, fourth payment, $240,000.
Weissenburg (C), fourth payment, $240,000.
Kurfürst Friedrich Wilhelm (D), fourth payment, $240,000.

ARMORED COAST-DEFENSE VESSELS Q, R, S, T, U, V, W, X.

Frithjof (Q), fourth and last payment, $144,000.
R, third and last payment, $288,000.
S, second payment, $370,000.
T, first payment, $360,000.

U, second payment, $370,000.
V, first payment, $360,000.
A proposed first payment on W was stricken out.

FIRST-CLASS PROTECTED CRUISERS H, J, K, L, M, N, O, P.

Kaiserin Augusta (H), fifth payment, $240,000.
Cruiser J, second payment, $120,000.
A proposed first payment on cruiser K was stricken out.

Unprotected cruiser *Cormoran* (E), third and last payment, $84,000.
A first payment on cruiser F was stricken out.

Imperial yacht and dispatch vessel, third and last payment, $370,000.
A first payment on the *Dispatch boat H* was stricken out.

VESSELS LAUNCHED.

BRANDENBURG (A)—WEISSENBURG (C).

(Page 46, No. X.)

These two battleships have been launched at the Vulcan Works, Stettin; the former in September and the latter in December, 1891.

The following are their chief characteristics:

Armament.—Six 11-inch Krupp B. L., in three turrets or covered barbettes; six 4.1-inch R. F., in a casemate between the two forward barbettes; eight 3.4-inch R. F., on bridges and superstructure; a number of lighter rapid-fire guns, and seven torpedo tubes.

Protection.—Waterline belt, 11.8 to 15.75 inches thick; barbettes and conning tower, 11.8 inches; casemate, 3 inches; tubes, 11.8 inches; a complete cofferdam belt filled with water-excluding material; collision bulkheads forward and aft with complete double bottom between them; protective deck, steel, complete, 2.56 inches thick.

(It was at first intended to give all of these ships compound armor, but it is now probable that the last two of them will have nickel-steel.)

Motive power.—Vertical triple-expansion engines of 8,000 H. P., to give 15.5 knots speed.

Dimensions.—Length, 377 feet, 4 inches; beam, 63 feet, 11 inches; depth, 36 feet; draught, 24 feet, 3 inches; displacement about 10,000 tons.

FRITHJOF (Q).

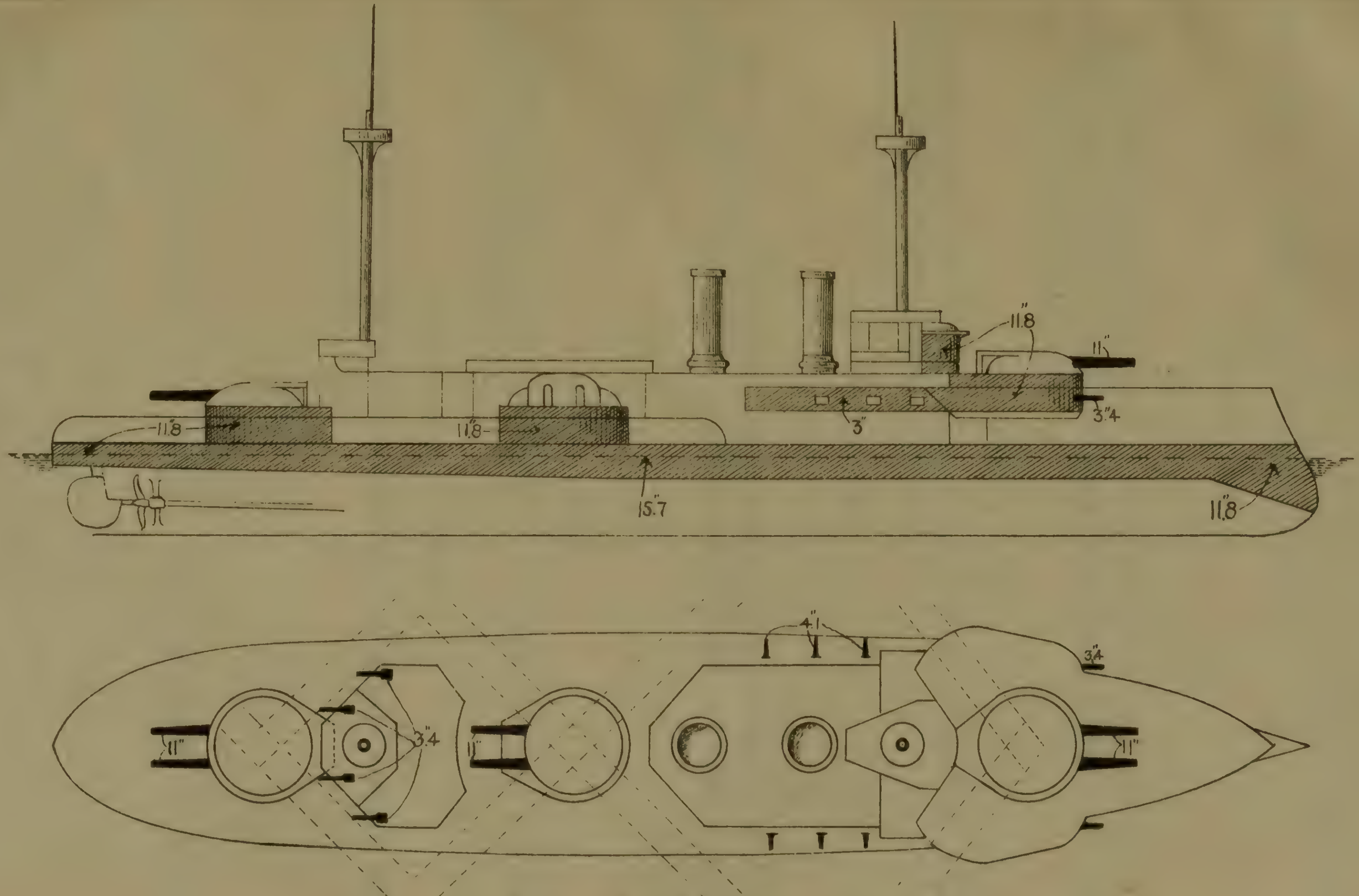
Third of the coast defense vessels (*Siegfried* type, page 46, No. X), was launched at Bremen on July 21, 1891.

KAISERIN AUGUSTA (H).

(Page 46, No. X.)

Protected cruiser, launched at Kiel on January 15, 1892.

The original designs of this vessel have been much modified since



KURFURST FRIEDRICH WILHELM

Kreigs Flotten.

they were first made public. She is now to have three propellers instead of two, as then contemplated, and her displacement has been increased from 5,500 to 6,052 tons. Her armament will consist of twelve 5.9-inch B. L.; eight 3.4-inch R. F., and five torpedo tubes, one of the latter being fixed in the bow, some 13 feet under water.

SEEADLER—KONDOR.

(Page 46, No. X.)

These two unprotected cruisers, which were built to take the place of the *Eber* and *Adler*, lost at Samoa, were launched at Hamburg in February and March of this year.

CORMORAN.

Formerly known as the unprotected cruiser *E*, was launched at the Schichau works, Dantzig, on May 17, 1892.

HOHENZOLLERN.

(Page 47, No. X.)

Imperial yacht and dispatch vessel, was launched at Stettin on June 27, 1892. The old yacht *Hohenzollern* has had her name changed to *Kaiseradler*.

STEAM TRIALS.

PRINCESS WILHELM.

Protected cruiser of 4,400 tons displacement (page 355, No. VIII), has made 18 knots with 8,500 I. H. P.

TORPEDO DIVISION BOAT NO. 7.

A torpedo vessel of 350 tons displacement, is said to have made on trial 26 knots with about 4,000 I. H. P.

BEOWULF (P).

(Page 47, No. X.)

This coast defense armor-clad made 15 knots during her unofficial trials at Bremen.

VESSELS LOST OR STRUCK FROM THE LIST.

Bismarck, unprotected cruiser, condemned in 1891.
Musquito, training brig, condemned in 1892.
Falke, paddle dispatch vessel, condemned in 1892.
Pommerania, dispatch vessel, sold in 1892.

TORPEDO BOATS.

(Page 49, No. X.)

The last payment of $259,200 is provided in the Budget of 1892–'93 for eight torpedo boats which were commenced last year, and a first payment of $528,000 is to be expended on eight new boats which will soon be laid down.

The following old boats were condemned in 1891 and struck from the Navy List: *Flink, Kühn, Scharf, Schütze, Sicher, and Vorwarts.*

SPAIN.

The Naval Estimates for 1892, as approved by Parliament on July 6, 1891, amount to $7,444,101. In addition to the above, the sum of $17,400,000 is to be expended on the construction of war vessels; this expense being incorporated in the extraordinary budget of $45,000,000 voted on June 7, 1888, in accordance with the law of January 12, 1887, concerning the construction of the Spanish fleet.

VESSELS PROPOSED OR LAID DOWN.

Four torpedo vessels of about 750 tons displacement are said to have been recently ordered from private contractors.

VESSELS LAUNCHED.

VISCAYA—OQUENDO.

Armored cruisers, sisters to the *Infanta Maria Teresa*, were launched at Bilboa on July 8 and October 4, 1891.

As the original plans (page 318, No. VII) have been somewhat modified, the following description is given:

Armament.—Two 11-inch Hontoria B. L. in turrets on centre line forward and aft; ten 5.5-inch Hontoria R. F. in the waist on upper deck; eight 6-pounder and ten 1-pounder R. F.; eight Nordenfeldts and two Maxim machine guns; eight torpedo tubes (two submerged).

Protection.—Water-line belt 216 feet long and 10 to 12 inches thick, covers magazines and machinery; turrets 9 inches thick; conning tower 12 inches; protective deck 2 to 3 inches, with 8-inch inclined armor over top of cylinders.

Motive power.—Triple-expansion engines to give 13,000 I. H. P. and 20 knots speed.

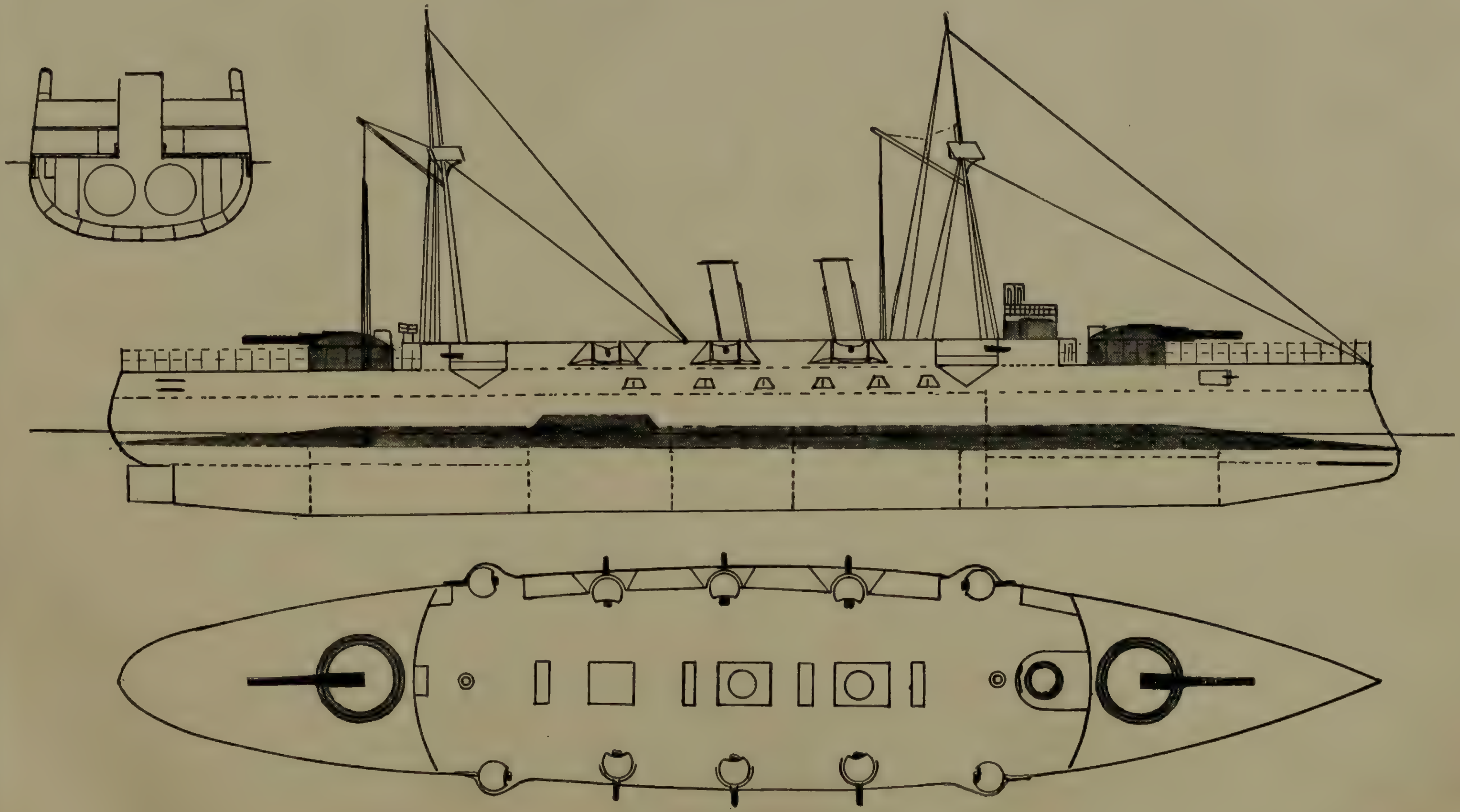
Dimensions.—Length, 364 feet; beam, 65 feet; depth, 38 feet; draught, 22 feet; displacement, 6,890 tons.

The work on these cruisers has been considerably delayed, owing to financial embarrassments of the Nervion Company.

Their yard was closed for three weeks and all the workmen thrown out of employment until May 16, when it was reopened under what are considered by the English as favorable conditions.

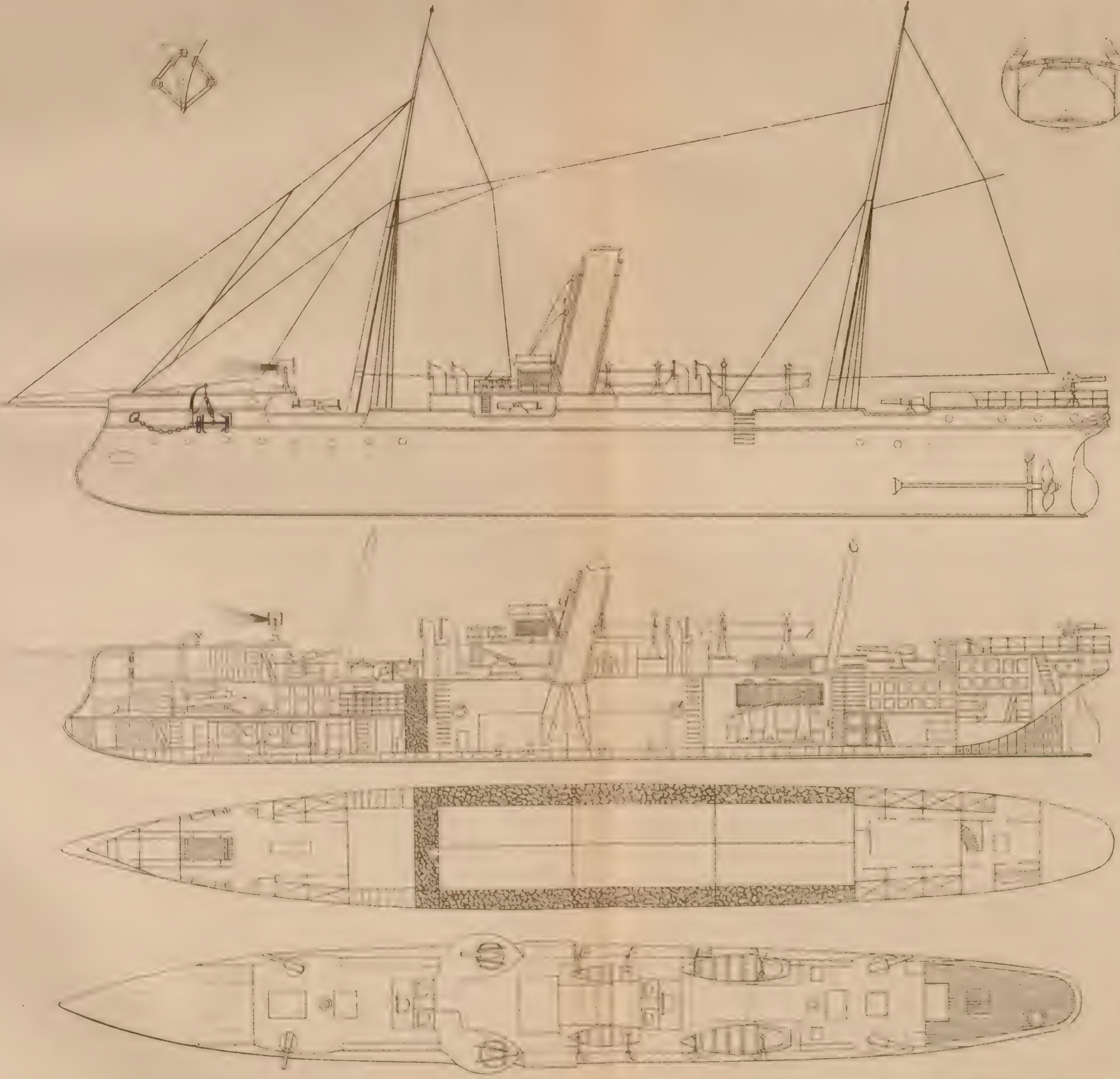
ARMORED CRUISERS.

Infanta Maria Teresa.
Almirante Oquendo.
Viscaya.



The Naval Annual
LORD BRASSEY

TORPEDO VESSEL NUEVA ESPAÑA



Revista General de Marina

The Spanish Government, who, under the terms of the guarantee, were empowered to take possession of the works and to cancel the original contract, have made an arrangement with Sir Charles Palmer to take charge of the technical direction of the construction, and under this arrangement the contracts with all the English managers and operatives are taken over and guaranteed by the Government.

The Government also holds itself responsible for all the contracts which have been entered into by the company in England and elsewhere for material of all kinds to be used in the construction of the cruisers.

ALFONSO XIII.

This 4,800-ton protected cruiser was laid down at Ferrol in 1888, but not launched until August 31, 1891. Her armament consists of four 7.87-inch Hontoria B. L.; six 4.72-inch Hontoria B. L.; twelve R. F.; two machine guns, and five torpedo tubes; protective deck complete; engines of 11,500 I. H. P., to give 20 knots.

RAPIDO—GALICIA.

Torpedo-vessels of the *Temerario* type (570 tons, page 42, No. IX) launched in June and August, 1891.

The following description of the *Nueva España* applies to the other five ships of her class.

Armament.—Two 4.72-inch Hontoria B. L. on sponsons amidships; four 6-pounder Nordenfeldt R. F.; one machine gun and two torpedo-tubes.

Protection.—Steel deck over engines and boilers; coal forward of and at sides of machinery.

Motive power.—Two triple-expansion, vertical engines of about 2,600 I. H. P., to make 210 revolutions with forced draft.

With the two after boilers only and natural draft, 800 I. H. P. is expected. The boilers are four in number, of two different types, the forward ones being locomotive and the after ones ordinary cylindrical.

This arrangement is said to work well, enabling the ships to serve as ordinary gunboats in time of peace and as fast torpedo-vessels in time of war, thus gaining in general utility.

STEAM TRIALS.

TEMERARIO.

Trials which took place at the close of last year gave very satisfactory results—20.5 knots with forced draft and 16.5 with natural draft.

TORPEDO-BOATS.

Mr. J. S. White, of East Cowes, is now executing an order of the Spanish Government for four wooden torpedo-boats, which are fitted as life-boats.

They are 60 feet long by 9 feet 4 inches beam, and are provided with compound surface condensing engines and locomotive boilers. Trials of the first of these boats, which took place last May, in the Solent, exceeded the contract requirement, the mean of six runs on the measured mile being 18.346 knots, when only 17¾ had been guaranteed.

They will be armed with Whitehead torpedoes and machine guns, and will cost about $12,125 apiece.

AUSTRIA.

The Naval Estimates for 1892 amount to $4,185,977.

The following sums are to be expended on construction and repair:

Armored cruiser C, third payment, $316,800.
Mine vessel *Salamander*, third and last payment, $15,120.
Danube monitor *Koros* (formerly *Theiss*), last payment, $14,400.
Danube monitor *Szamos* (No. II), second payment, $72,000.
Protected cruiser *Kaiserin Elisabeth*, fifth payment, $90,720.
Torpedo-depot ship *Pelikan*, last payment, $38,160.
Tank vessel *Naiade*, third and last payment, $7,200.
New machinery for the *Tegetthoff*, second and last payment, $158,400.
New guns for the *Tegetthoff*, $57,600.
Torpedo vessel *Satellit*, second payment, $48,240.
Improvement of the armor-clad *Erzherzog Albrecht*, $18,000.

Admiral Von Sterneck, Marine Commandant, was asked during the discussion of the Naval Budget whether it was to be understood that the Austrian naval authorities were content with the present floating strength. He replied that, on the contrary, the Admiralty were well aware of deficiencies.

Of the eleven armor-clads, three only were battle-worthy, and two others, though provided with a good armament, were defective in speed. The three ships of the *Kaiser Max* class, by reason of their small displacement and low speed, could not be counted upon, and the same was true of the wooden ships *Lissa*, *Kaiser*, and *Habsburg*.

It was therefore very necessary to take in hand the work of replacing the old battle-ships, for in regard to new construction, even when compared with the smaller powers, Austria was falling more and more in the background.

He should think himself fortunate if the Committee would take his explanation and support him, so that later on provisions might be made for the building of six new armor-clads.

This report of Baron von Sterneck, which opens up the prospect that extensive naval grants will be required in the future, was approved by the Austrian Delegation, but it is understood that the construction of the armor-clads will not be begun during the next year.

As shown in the Budget, the coming twelve months will be devoted to continuing work on ships already laid down, or to repairing and improving ships already in commission.

A first installment on three new armored cruisers was asked for in the Budget of 1893, but the Ministerial Council have found it necessary to strike out the appropriation.

STEAM TRIALS.

KAISERIN ELISABETH.

(Page 53, No. X.)

This 4,000-ton protected cruiser has given most satisfactory results on her trials. She obtained 19.7 knots with forced draft and 18.6 with natural draft.

PLANET.

This torpedo vessel having undergone many alterations, has at last been accepted by the Austrian Government.

She attained a speed of 19.6 knots on her final trial, and during her passage out from England encountered very rough weather, during which the ship behaved well, and the action of her engines was perfect.

PELIKAN.

(Page 53, No. X.)

This torpedo-depot ship has been recently delivered to the Austrian Government by Mr. Schichau, of Elbing, her trials having been very successful. The contract only called for a speed of 16.5 knots with forced draft, but on trial a mean speed of 18.3 knots was attained with natural draft and 4,700 I. H. P. No difficulty was experienced in making steam, and the coal consumption is said to have been but 1.65 pound per I. H. P. per hour.

The *Pelikan* was built to carry supplies of spare gear, coal, torpedoes, and ammunition to a fleet of torpedo boats, and to execute repairs of the fleet, for which purpose she is fitted with a couple of workshops.

CHINA.

KUANG KENG—KUANG YI—KUANG PING—KUANG TING.

Small protected gun vessels, have been recently completed at the Foochow arsenal.

Armament.—Three 4.72 inch Armstrong R. F. G., twelve light R. F. G. and four torpedo tubes. (At last accounts no tubes had been fitted.)

Protection.—A complete steel deck, 1 inch thick, and a 2-inch conning tower. Gun shields.

Motive power.—Horizonal compound engines of 2,400 I. H. P. (The *Kuang Yi* has made 16.5 knots on trial.

Dimensions.—Length, 236 feet; beam, 27 feet, 6 inches; depth, 18 feet, 7 inches; mean draught, 12 feet; displacement, 1,030 tons.

CHILE.

The Naval Estimates for 1892 amount to $7,576,542.

The transports which were hired or seized during the late civil war have all been disarmed and returned to their owners.

Two steamers, the *Aquila* and *Spartan*, were bought in Europe, and would probably have served as armed transports or cruisers had they been available in time. They are still owned by the Chilean Government, but it is not known what use they are to be put to.

Many contradictory reports have been received as to the intention of the present Ministry to buy cruisers and armor-clads abroad, but no definite steps seem to have been yet taken, and President Montt, at the opening of Congress, June 1, 1892, stated that it was not intended, at present, to raise the strength of the navy.

Proposals to raise the *Blanco Encalada* have been received, and the specifications, plans, etc., referred to a Commission for examination and report.

STEAM TRIALS.

CAPITAN PRAT.

This armored cruiser is said to have had successful trials during which she made about 18 knots.

DENMARK.

The Naval Estimates for the financial year 1892–'93 amounted to $2,267,408, the following sums being devoted to new construction:

ORDINARY EXPENDITURES.	
Cruiser *Geiser*	$100,980
Cruiser *Heimdal*	183,330
New armor-clad	39,528
EXTRAORDINARY EXPENDITURES.	
Cruisers *Geiser* and *Heimdal*	81,000
New torpedo boat	*37,800
Submarine mines and torpedoes, partly for completing the defenses of Copenhagen and partly for armoring the *Geiser*	113,400

---

*Total estimated cost, $89,100.

HEIMDAL.

This cruiser was laid down early in 1891. She is to have 1,280 tons displacement and a speed of 17.5 knots.

HJÄLPEREN.

A mine vessel, has been recently added to the Danish fleet. She is 122 feet long, 21.5 feet beam, and about 250 tons displacement.

VESSELS LAUNCHED.

GEISER.

Protected cruiser of 1,300 tons displacement (page 47, No. IX), has been recently launched. Her armament will consist of four 3.42-inch Krupp R. F., six 37^{mm} R. C., and four torpedo tubes.

TORPEDO BOATS.

SPRINGEREN.

(Page 47, No. IX.)

This boat was completed at the Royal Dockyard, Copenhagen, in 1891. She is fitted with Thornycroft engines and boilers and has made 18.3 knots on trial. Displacement, 86 tons. Armament, two bow tubes and two 37^{mm} R. C.

HOLLAND.

VESSELS PROPOSED OR LAID DOWN.

BELLONA.

Gunnery schoolship. Keel laid at the Government works, Amsterdam, in 1891.

Armament.—One 5.9-inch B. L.; seven 4.72-inch B. L., and ten lighter guns.

ZEEHOND.

A small steamer commenced at Amsterdam in 1891.

VESSELS LAUNCHED.

REINIER CLÆSEN.

(Page 58, No. X.)

Coast-defense vessel, launched in 1891.

STEAM TRIALS.

SUMBAWA—LOMBOK—PELIKAAN—FLAMINGO.

Four small gun vessels that have been recently completed in Holland for the Dutch East Indian Government.

Their trials have been successful. The *Sumbawa* and *Lombok* (576 tons) obtained about 12.5 knots with 900 to 1,000 I. H. P. and the *Pelikaan* and *Flamingo* (400 tons) 11.35 knots with 485 I. H. P.

TORPEDO BOATS.

STEAM TRIALS.

The *Nobo* (page 60, No. X) had her official trials on July 24, 1891.

Displacement on trial, 50.5 tons; mean draught, 2 feet, 10 inches; revolutions, 477; I. H. P., 787; speed during two hours, 20.71 knots.

This boat was built at the Government works, Amsterdam, and her machinery by the Schelde Company of Vlissengen.

The official trial of torpedo boat No. 111 took place on November 3, 1891.

Displacement on trial, 37 tons; boiler pressure, from 160 to 170 pounds; vacuum, 23 to 24 inches; revolutions, 443.1; I. H. P., 449; speed, 17.9 knots.

JAPAN.

Messrs. Armstrong, Mitchell & Co. are now building a fast twin-screw protected cruiser for the Government of Japan, of which the following are the leading particulars:

Armament.—Four 6-inch, eight 4.7-inch, and twenty-five smaller rapid-fire guns, and six torpedo tubes.

Protection.—Steel deck, complete, 1.75 inches thick on the flat and 3.5 to 4.5 inches on the slopes.

Motive power.—Engines of 1,500 H. P. to give 23 knots speed. Coal supply, 1,000 tons.

Dimensions.—Length, 350 feet; beam, 45 feet; draught, 16.5 feet; displacement, 4,200 tons.

STEAM TRIALS.

MATSUSHIMA.

(Page 62, No. X.)

This coast-defense vessel has succeeded in obtaining more than the contract speed (16 knots) on trial, but the fire rooms were excessively hot.

TORPEDO BOATS.

The first of sixteen boats now building at the Onohama shipbuilding yard has been successfully tried, and it is expected that the remaining fifteen will be completed within the next year.

NORWAY.

VESSELS PROPOSED OR LAID DOWN.

In the Estimates for 1892 the sum of $185,360 will be devoted to the construction of new ships. It will be divided in the following manner:

To continue the construction of a second-class gun vessel	$57, 680
For the construction of two new torpedo boats	42, 000
For an experimental ship	18, 480
For two small transports	33, 600
For modifications in the gunboats *Rjukan* and *Serpen*	33, 600

The Military Commission has reported favorably on a proposition of the Minister to build an armored coast-defense vessel of the *Svea* type.

VESSELS LAUNCHED.

VIKING.

Protected cruiser of 1,113 tons displacement (page 49, No. IX), was launched in 1891.

TORPEDO BOATS.

ORM—OTER.

Two 40-ton boats completed at the Government yard at Horten during 1891. They carry two torpedo tubes and one 37 ^{mm} R. C. and are to make 18.5 knots speed.

SWEDEN.

VESSELS PROPOSED OR LAID DOWN.

The Naval Budget for 1892 provides for the laying down of a fourth coast defense vessel of the *Svea* type, to cost $834,200, and a further sum of $339,500 to be expended on the *Thule.*

An additional grant of $533,500 was also demanded, but is understood to have been refused by the Riksdag.

THULE.

Coast-defense armor-clad, of the *Svea* class (page 212, No. V), was laid down in the autumn of 1891 at Finnboda, Sweden.

Messrs. Armstrong, Mitchell & Co. will supply the two 10-inch guns, with their appurtenances, and M. Schneider & Co., of Creusot, have secured contracts for the vertical armor.

SVENSKSUND.

Gunboat and general-service vessel has been recently added to the Swedish Navy.

She will be armed with four Nordenfeldt guns and torpedoes, but her equipment is such that she will prove more useful in time of peace than in war. She is a powerful tug and ice breaker, fire vessel, tank boat, and torpedo-repair ship.

A centrifugal pump is fitted which is capable of delivering 2,200 cubic feet of water per hour, and her condensers furnish 800 gallons during the same time.

Her displacement is 280 tons and estimated speed about 13 knots.

TORPEDO BOATS.

GONDUL—GUDUR.

In course of construction.

PORTUGAL.

The proposed building programme seems to be at a standstill, owing to the financial embarrassments of the Government. None of the armored cruisers (page 64, No. X) are known to have been laid down, and the only new construction recently undertaken is that of a 25-ton torpedo boat and an experimental submarine boat, on the plans of Señor Fontes Pereira, which has been ordered by the naval authorities.

VESSELS LAUNCHED.

CUERVO.

A 71-ton gun-boat launched at Barcelona on December 14, 1891. Her trials took place in March, 1892, when she made 13.72 knots with forced-draft and 11.3 knots with natural draft.

BRAZIL.

VESSELS PROPOSED OR LAID DOWN.

BENJAMIN CONSTANT.

The Société des Forges et Chantiers de la Mediterranée received an order last summer to build a schoolship for the Brazilian Government. Her principal characteristics are:

Armament.—Four 5.5-inch R. F. in barbette turrets, two on forecastle and two on the poop; eight 5.5-inch B. L. in broadside on main deck; eight light R. F. and four torpedo tubes.

Protection.—Complete protective deck.

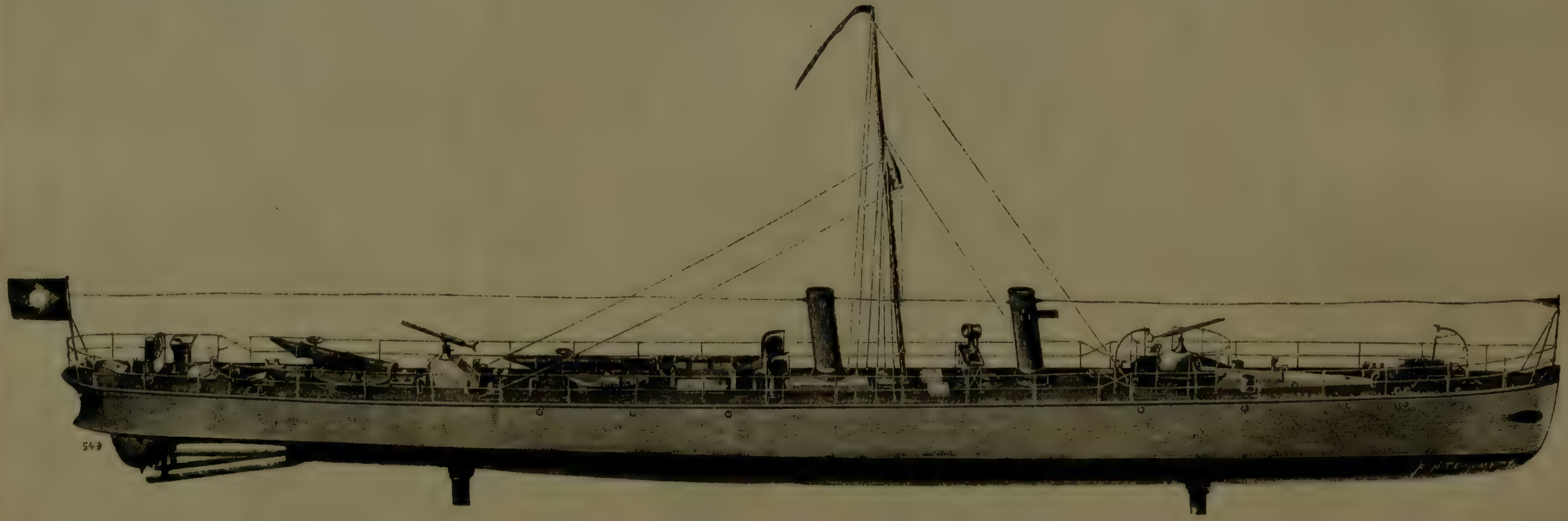
Motive power.—Engines of 2,800 I. H. P., to give 14 knots speed.

Dimensions.—Length, 236.2 feet; beam, 44.6 feet; depth, 26.9 feet; mean draught, 18 feet; displacement, 2,750 tons.

She has been given the above name, and at last accounts was nearly ready for launching.

SEAGOING TORPEDO BOAT FOR THE BRAZILIAN NAVY.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., ENGINEERS, LONDON.



Engineering.

It is understood that tenders have been invited for a fast cruiser of about 3,500 tons displacement, similar to the one recently completed at Elswick.

VESSELS LAUNCHED.

REPUBLICA.

A twin-screw protected cruiser, launched by Messrs. Armstrong & Co., at Elswick, on May 26, 1892.

Armament.—Six 4.7-inch R. F., four 6-pounder R. F., six machine guns, and four torpedo tubes.

Protection.—Steel deck 1 inch thick on the flat and 2 inches on the slopes.

Motive power.—Engines of 3,300 I. H. P., to give 17 knots speed. Coal supply, 170 tons.

Dimensions.—Length, 210 feet; beam, 35 feet; draught, 13 feet; displacement, 1,300 tons.

TIRENDENTES.

A twin-screw gunboat, launched at the same time and place.

Armament.—Four 4.7-inch R. F., three 6-pounder R. F., four machine guns, and two torpedo tubes.

Motive power.—Engines of 1,200 H. P., to give 14.5 knots speed.

Dimensions.—Length, 165 feet; beam, 30 feet; draught, 11 feet; displacement, 800 tons.

This vessel is built of steel and sheathed with wood. She is to be used as a practice ship.

The four gunboats for service on the Amazon River (page 65, No. X) have been named *Jutahy*, *Jururema*, *Tocantins*, *and Teffé.*

VESSELS LOST OR STRUCK FROM THE LIST.

Solimoes, armored coast-defense vessel. Wrecked off the mouth of the Rio de la Plata, in May, 1892.

TORPEDO BOATS.

Three boats completed by Thornycraft in 1891 have been named *Iguatemy*, *Marcilio Dias*, and *Araguary.*

The remarkably successful trials of the first of these boats are described on page 66, No. X, and the *Marcilio Dias* has done nearly as well, making 25.1 knots on the measured mile and 24.1 during two hours.

ARGENTINA.

The present naval programme contemplates the ultimate increase of the torpedo fleet to forty boats, and the purchase of two new vessels;

one a protected cruiser recently completed by Messrs. Armstrong & Co., and the other a battle-ship, of light draft and great power, of about 4,000 tons displacement.

The cruiser is said to have been bought last April, the price, including armament, being $1,430,750.

She is similar to the *25 de Mayo*, her principal characteristics being:

Armament.—Four 6-inch, eight 4.7-inch, fourteen 3-pounder, and twelve 1-pounder rapid-fire guns, and six torpedo tubes.

Protection.—Deck 4.5 inches thick on the slopes and 1.75 inches on the flat; conning tower, 3-inch steel.

Dimensions.—Length, 330 feet; beam, 41 feet; draught, 16.5; displacement, 3,500 tons.

TORPEDO BOATS.

MURATURE.

(Page 68, No. X.)

This Thornycroft boat was sent out from England last winter, and during the passage encountered several heavy gales which thoroughly tested her seagoing qualities. She is said to have behaved remarkably well, taking very little water on board except on one occasion in the Bay of Biscay, when an unusually heavy sea struck her on the quarter, broaching her to and sweeping the decks aft, carrying away a boat and doing other damage.

The run from Pernambuco to La Plata, a distance of about 2,300 miles, was made without stopping, the average speed, under one engine only, being 9½ knots.

Her highest speed with one engine is about 16 knots, and with both running at full speed (491 revolutions) she made 24.6 knots on trial.

The steaming radius is 2,800 miles, at 9½ knots, in moderate weather.

Another point that has been noted concerning this boat is that her speed is reduced surprisingly by the shallowness of the water in the La Plata River.

Some reduction was of course to be expected, as in the case of other boats and ships, but it was especially marked with the *Murature.* On one occasion, when coming down the Parana in about 60 feet of water, she made 20 knots, and half an hour later, in the Rio de la Plata, in about 15 feet of water, and with the same number of revolutions, she was found to be making only 15 knots.

This great difference in her performances has been attributed to the flatness of the after section of the boat.

JORGE—KING—PINEDO—BUCHARDO—THORNE—BATHURST.

(Page 68, No. X.)

The six first-class Yarrow boats have received the above names; they have all been delivered and are now in commission.

MEXICO.

VESSELS PROPOSED OR LAID DOWN.

Four small gun boats are now being constructed by the Mexican Government for duty on the coast.

STEAM TRIALS.

ZARAGOZA.

(Page 70, No. IX.)

This school-ship had successful steam and gun trials in July, 1891, and has been accepted. The mean of four runs on the measured course gave 1,291 I. H. P. and 14.69 knots speed. Her battery is now said to consist of six 4.72-inch B. L., two 3-pounder R. F., and two 37^{mm}. R. C.

PERU.

According to an official report of the Minister of War and Marine, dated May 6, 1891, the navy consisted at that time of the following vessels:

LIMA.

Partially protected cruiser of 1,790 tons displacement and 2,000 I. H. P., armed with two 6-inch Armstrong B. L., three 3-pounder R. F., and two Maxim machine guns.

SANTA ROSA.

Transport of 333 tons displacement and 110 I. H. P., armed with two 3.4-inch and one 2.7-inch Krupp B. L., and two Maxim machine guns.

PERU.

Hulk, used as a school-ship.

TURKEY.

VESSELS PROPOSED OR LAID DOWN.

Very little has been done in the way of rehabilitating the Turkish fleet, probably on account of the lack of funds, but it is understood that tenders have been recently invited in France and England for the construction of one armor-clad and five gun vessels.

The keel of a transport named the *Shadié* was laid at the arsenal of Constantinople on November 9, 1891.

HAITI.

DEFENSE.

This war vessel was formerly an English merchant steamer named the *Belize.* She is described as being a small steamer of some 1,100 tons displacement with one smoke pipe and two pole masts. Armament: One 3.9 inch Canet B. L. on C. P. mount forward, protected by a shield; two 3.9-inch Krupp B. L.; two 12-pounder howitzers, and two Gatling machine guns.

DESSALINES.

The armament of this cruiser at present consists of one 3.9-inch Canet B. L. on C. P. mount forward, protected by a shield; two 3.9-inch Krupp B. L.; two 3.9-inch Armstrong B. L.; two 30-pounder Parrott rifles, and two Gatling machine guns.

BULGARIA.

Several gunboats are said to have been ordered in England for service on the Danube River, and contracts for two warships for the defense of the port of Varna have been given to Orlando Brothers, of Leghorn.

ROUMANIA.

Plans have recently been invited from the *Stabilimente Technico* of Trieste for three river gunboats of the monitor type similar to those building at Buda-Pesth for Austria.

SIAM.

MAHA CHAKRKRI.

A steel twin-screw cruiser, to be used also as a transport and royal yacht, was launched at the works of Messrs. Ramage & Fergusson of Leith, on June 27, 1892.

She is to have about 2,500 tons displacement, will carry four 4.7-inch and ten 6-pounder R. F. G, and is expected to make from 17 to 18 knots speed.

COSTA RICA.

A second-class torpedo boat has been recently built for this Government by Messrs. Yarrow & Co. She is similar to the English boats of the same class.

Charles E. Fox,
Lieutenant, U. S. Navy.

II.

NOTES ON MACHINERY.

UNITED STATES VESSELS.

MACHINERY UNDER CONSTRUCTION.

As Congress has not during the past year authorized the construction of any new vessels, there are no new designs of machinery to be reported upon. The only machinery contracted for during the same period was that of Cruiser No. 13 and that of Torpedo-boat No. 2, for both of which abstracts of the specifications were given in General Information Series, No. X., 1891. The contract for the machinery of the former vessel was awarded, August 31, 1891, to Messrs. Cramp, of Philadelphia, and that for the machinery of the torpedo-boat was awarded, October 8, 1891, to the Iowa Iron Works, of Dubuque, Iowa.

The following changes, with others of lesser importance, have been authorized during the year in machinery under construction, previously described:

Texas.—High and intermediate pressure piston valves to be made treble-ported instead of double-ported.

Monterey.—Pressure-reducing valves, four in number, to be fitted in the steam piping between the Ward and Scotch boilers.

Machias and Castine (*Gunboats Nos. 5 and 6*).—Two-cylinder simple engines substituted for compound engines for driving the air pump.

Bannister patent rocking grates substituted for the wrought-iron revolving or shaking grates specified.

Montgomery and Detroit (*Cruisers Nos. 9 and 10*).—Air-pump engine frames to be of cast iron instead of cast steel.

Propellers to be three-bladed instead of four-bladed.

Stern tubes to be made in two pieces, on account of the difficulty experienced in getting single castings.

Two-cylinder simple engines substituted for compound engines for driving the air pumps.

Kirkwood's shaking grates adopted.

Marblehead (*Cruiser No. 11*).—Frames for engines of air and circulat ing pumps to be of forged steel instead of cast steel.

Cruiser No. 6.—Main engine bed-plates to be made of manganese bronze instead of cast steel.

Front engine columns (cylindrical) to be made of wrought steel instead of cast steel.

Y-frames for back of main engines to be iron forgings instead of steel castings.

Cylinder-heads and valve-chest covers for main engines to be made of cast iron instead of cast steel.

Crossheads for main engines to be made of forged steel instead of cast steel, and crosshead slippers of phosphor bronze instead of cast steel.

Valve-stem crossheads to be made of forged steel instead of cast steel.

New York.—Height of smoke pipes above grates increased 9 feet.

Outboard section of propeller shaft increased in diameter ¼ inch.

Cast gun-iron substituted for cast steel for Y-frames.

Manganese bronze substituted for cast steel for valve-stem crossheads.

Blake air pumps substituted for the single-acting vertical air pumps originally specified.

Cramp's steam reversing gear substituted for the form originally specified.

Auxiliary condensers of the Wheeler type adopted.

Cruisers Nos. 12 and 13.—Cylinder-heads to be made of cast iron instead of cast steel.

Crossheads to be made of forged steel instead of cast steel.

Valve-stem crossheads to be made of manganese bronze instead of cast steel.

Auxiliary condenser specified for after (middle) engine-room to be omitted, and the capacities of the auxiliary condensers in the two other engine-rooms to be increased accordingly, the auxiliary condensers adopted to be of the Wheeler type.

Location of thrust bearing of middle shaft altered, and disc couplings substituted for clutch couplings.

Indiana and Massachusetts.—Y-frames for main engines to be made in two pieces instead of single castings.

Valve-stem crossheads to be made of manganese bronze instead of cast steel.

Blake air pumps substituted for those originally specified.

Auxiliary condensers of Wheeler type adopted.

Curved upper sheets of boiler fronts dispensed with and flat fronts substituted.

Oregon.—Main engine bed-plates to be made of manganese bronze instead of cast steel.

Y-frames for main engines to be made of forged iron, and cylindrical columns to be made of forged steel, instead of cast steel.

Main crossheads and valve-stem crossheads to be made of forged steel instead of cast steel.

Caps for main bearings to be made of bronze instead of cast steel.

A mortise-wheel with wooden teeth and a bronze pinion substituted for the cast-steel gear-wheel and rawhide pinion originally specified for the driving mechanism of the air pump.

Closed ash-pit system of forced draft adopted for the auxiliary boilers.

Harbor-defense Ram.—Main engine bed-plates to be made of gun-iron instead of cast steel.

Steel castings.—The fact will be observed, to which attention was called in the same connection in General Information Series, No. X., 1891, that many of the changes noted in machinery under construction consist in the substitution of other metals for cast steel where that material has been called for in the original specifications. In this connection the following extracts are quoted from the report of the Chief of the Bureau of Steam Engineering for the year 1891:

> I am again obliged to report that we are having most discouraging experience with steel castings, and that the statements in former reports concerning them can be repeated almost without change, for in some cases parts designed of cast steel have been "built up" of forged or rolled steel; in others the castings have been reinforced with plates of rolled steel; and in still others the castings have been made abnormally heavy and reduced to size in the shaper or planing machine.
>
> The publication of these reports has evidently directed considerable attention to this matter, and has elicited letters to the technical press from representatives of several of the steel-casting establishments. Without exception they admit that there have been many failures and delays, but they endeavor to escape the charge of poor work for the Government by stating that they have done better for other parties and by claiming that the designs for machinery call for shapes that can not be successfully cast in steel; they also imply that if the steel makers were allowed to modify designs and split one casting up into as many as they chose they could guarantee good work. One writer goes so far as to state that they do not claim any reduction of weight from the substitution of steel for iron, but that the parts will be so much stronger that there will be much less danger of a breakdown.
>
> Whatever truth there may be in the charge that some designers ask for shapes that can not be cast successfully in steel, it does not apply to the designs for the machinery of our new ships; for, without exception, the steel makers have been met in friendly spirit by the Bureau, and every change which they have suggested within reason has been allowed. But there must, of course, be a limit to this; we do not design machinery for amusement nor to ascertain if steel makers can cast the parts, but to answer certain very definite purposes. If cast steel will fill the requirements better than any other metal, we desire to use it; but if we are to be hampered by being limited to a few shapes, and having pieces which would be one easy casting in iron cut up into a number involving expensive machine work to fit together, and the uncertainty of bolted joints in the very places where simplicity and solidity are most needed, then the conclusion can not be avoided that steel castings are not desirable for such purposes.
>
> It is interesting to compare the attitude now taken by the steel makers with that assumed by them some seven or eight years since, when the first of our new vessels were building. They claimed then that they could cast anything in steel that could be cast in iron, and the Advisory Board (which was then responsible for the general designs of the ships and machinery) was criticised for its unwillingness to accept these statements without question and use steel castings for all parts of machinery. When it was found that a fair degree of success had been attained in steel casting they were taken at their word and given opportunity to show their capacity, and

now they claim that the shapes called for (which are neither intricate nor new) can not be cast.

It can not be too plainly stated nor too strongly emphasized that the only reason for using cast steel instead of cast iron is that advantage may be taken of its greater strength to reduce weights. There can be no greater absurdity than to make steel castings of the same size as those of cast iron with a view to greater safety if the strength of the iron casting is ample; steel castings cost four or five times as much as iron ones, and it would be a deliberate waste of public money to use material in this way. The same is true of the plan of making pieces of several parts bolted together.

The little progress made in the production of steel castings was proved in a marked degree with the engine columns of a certain ship. These were perfectly plain hollow columns, and in cast iron would have been the simplest kind of work; in cast steel every one was so imperfect that they could not be used. After the failure of these columns the steel makers claimed that they were of a shape impossible to cast in steel, but before the castings were found defective not one of the makers thought there would be the least trouble in making them.

I am loath to believe that we shall be obliged to permanently abandon steel castings, for if the processes of manufacture can be improved so that absolute reliance can be placed on the product, the question of light machinery for war vessels is rendered much easier of solution. Moreover, it has always been found possible in other promising lines of work to ascertain the causes of first failures and to remedy them, and I am inclined to believe that in time this will be done for steel castings, since one firm has already successfully produced forms that the other makers said could not be cast, and their manager has stated that it is simply a question of time and the education of superintendents and workmen before we can safely count on the production in cast steel of any form now made in cast iron.

TABLES OF DATA RELATING TO THE MACHINERY OF UNITED STATES VESSELS.

The following tables of data relating to the engines, boilers, and steam trials of a number of United States steel vessels in commission, originally compiled in the Bureau of Steam Engineering, have been already published in the *Journal of the American Society of Naval Engineers*, August and November, 1891. They are here reproduced in the belief that they will prove of general interest.

TABLE I.—ENGINES.

	Name of vessel	Philadelphia.	San Francisco.	Charleston.	Baltimore.	Newark.	Yorktown.	Concord.	Dolphin.	Petrel.	Vesuvius.	Chicago.	Boston.
General data	Type of engines	Two H. D. A. 3-X.	Two H. D. A. 3-X.	Two H. D. A. 2-X.	Two H. D. A. 3-X.	Two H. D. A. 3-X.	Two H. D. A. 3-X.	Two H. D. A. 3-X.	One V. D. A. 2-X.	One H. B. A. 2-X.	Two V. D. A. 3-X.	Two Beam 2-X.	One H. B. A. 2-X.
	I. H. P. (designed)	9,000	9,000	7,500	9,000	8,500	3,400	3,400	2,300	1,100	3,200	5,000	3,500
	Boiler pressure	160	158	95	135	160	160	160	90	100	160	100	90
	Revolutions per minute (designed)	.....	.....	125	110	115	150	150	75	130	.....	64	70
	Piston speed in feet per minute	.....	.....	750	770	766	750	750	600	715	.....	608	490
	Diameters of cylinders	38 58 86	42 60 94	44 85	42 60 94	34 52 76	22 31 50	22 31 50	42 78	25 46	21½ 31 34 34	45 78	54 74 74
	Stroke	40	36	36	42	40	30	30	48	33	20	57	42
Ratios	Ratio of H. P. cylinder to I. P. cylinder	1 to 2.35	1 to 2.05	.....	1 to 2.06	1 to 2.35	1 to 2	1 to 2	.....	.....	1 to 2.07	.....	.....
	Ratio of I. P. cylinder to L. P. cylinder	1 to 2.21	1 to 2.47	.....	1 to 2.47	1 to 2.14	1 to 2.61	1 to 2.61	.....	.....	1 to 2.40	.....	.....
	Ratio of H. P. cylinder to L. P. cylinder	1 to 5.21	1 to 5.07	1 to 3.77	1 to 5.09	1 to 5.01	1 to 5.22	1 to 5.22	1 to 3.44	1 to 3.38	1 to 5.00	1 to 3	1 to 3.75
Cylinders	Material of cylinders	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.
	Material of liners	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	Cast iron.	.....	Cast iron.	Cast iron.
	Thickness of H. P. cylinder; of liner	1½ 1¼	1½ 1⅜	1¼ 1⅜	1¾ 1⅛	1½ 1¼	1 1	1 1	1⅛ 1⅛	1 1	⅞	1¼ 1¼	1⅜ 1½
	Thickness of I. P. cylinder; of liner	1½ 1¼	1¾ 1½	.....	1⅝ 1¼	1½ 1¼	1 1	1 1	.....	.....	⅞	.....	.....
	Thickness of L. P. cylinder; of liner	1½ 1¼	1¾ 1½	1¾	2¼ 1 7/16	1½ 1¼	1 1	1 1	1¼ 1¼	1 1	⅞	1¼ 1¼	1½ 1½
	Port opening for steam and exhaust, sq. ins.* H. P.	99 137 177	139 143 204	150 150 219	144 144 176	107 81 145	43 31 54	41 33 59	105 105 140	72 65 72	46 35 59	119 133 140	134 134 189
Port openings	Port opening for steam and exhaust, sq. ins.* I. P.	198 275 354	270 253 423	.....	252 252 366	136 198 257	49 68 94	57 78 100	.....	.....	63 86 116	.....	.....
	Port opening for steam and exhaust, sq. ins.* L. P.	327 406 571	487 489 704	307 349 559	487 487 675	272 395 515	114 156 211	110 129 225	216 216 275	200 182 200	63 86 116	237 237 300	191 187 285
	Velocity, entering and exhaust steam, ft. per sec.* H. P.	149 108 83	125 118 83	117 116 80	130 130 106	120 153 87	116 160 91	117 146 82	132 132 99	79 88 79	117 155 92	165 131 124	144 144 102
Steam velocities	Velocity, entering and exhaust steam, ft. per sec.* I. P.	176 127 98	131 138 85	.....	153 153 105	221 150 116	200 146 105	168 123 96	.....	.....	179 131 97	.....	.....
	Velocity, entering and exhaust steam, ft. per sec.* L. P.	235 172 135	178 176 126	215 190 120	195 195 141	237 162 125	225 165 122	226 193 110	221 221 174	97 106 97	214 158 117	221 221 175	190 194 127
Valves	Number, type, and size of valves, H. P	One piston, 21 dia.	Two piston, 12 dia.	Two piston, 13 dia.	One slide, 42×42.	One piston, 18 dia.	One piston, 9 dia.	One piston, 9 dia.	One slide, 44×99.	One piston, 15 dia.	One piston, 11 dia.	One slide, 43×51.	Two slide, 28×46
	Number, type, and size of valves, I. P	Two piston, 21 dia.	Two piston, 20 dia.	.....	One slide, 52×64.	One piston, 30 dia.	One piston, 15 dia.	One piston, 15 dia.	.....	.....	One piston, 18 dia.	.....	.....
	Number, type, and size of valves, L. P	Two piston, 32 dia.	Two slide, 50×57.	Two piston, 26 dia.	One slide, 66×88.	Two piston, 30 dia.	Two piston, 17 dia.	Two piston, 17 dia.	One slide, 60×63.	Two piston, 16 dia.	One piston, 18 dia.	One slide, 59×63.	Two slide, 37×46
	Diameter of valve stems: H. P.; I. P.; L. P	3½ 3½ 3½	4 4 4	3½ 3½	3¼ 3¼ 4	2⅞ 3½ 3½	2½ 2½ 2½	2½ 2½ 2½	3½ 3½	2¾ 2¾	2½ 2½ 2½	3 (Two) 3 (Two)	2¾ 2¾
	Type of valve gear	Marshall.	Stephenson.	Marshall.†	Stephenson.	Marshall.	Marshall.	Marshall.†	Stephenson.	Marshall.†	Marshall.	Stephenson.†	Stephenson †
Steam pipe	Diameter of main steam pipe	15½	13½	13½	15	12½	8	8	13	9	9	13	17
	Thickness of main steam pipe	No. 0 B. W. G. = .34	No. 3 B. W. G. = .26	No. 3 B. W. G. = .26	No. 3 B. W. G. = .26	No. 2 B. W. G. = .28	No. 5 B. W. G. = .22	No. 5 B. W. G. = .22	No. 7 B. W. G. = .18	No. 5 B. W. G. = .22	No. 5 B. W. G. = .22	No. 2 B. W. G. = .28	No. 3 B. W. G. = .26
Exhaust pipe	Diameter of main exhaust pipe	30	30	24	30	22½	18	18	Two, 8 × 30.	16	13½	22	19
	Thickness of main exhaust pipe	No. 7 B. W. G. = .18	No. 7 B. W. G. = .18	.....	.....	No. 7 B. W. G. = .18	No. 10 B. W. G. = .13	No. 10 B. W. G. = .13	.....	No. 10 B. W. G. = .13	No. 10 B. W. G. = .13	No. 5 B. W. G. = .22	No. 10 B. W. G. = .13
Steam velocities	Mean velocity in main steam pipe	78	118	122	106	103	98	96	105	89	85	131	84
	Mean velocity in main exhaust pipe	109	126	146	134	161	101	98	99	96	95	155	128
Pistons	Type of pistons	Conical disc.	Conical disc. ‡	Conical disc.	Conical disc.	Conical disc.	Conical disc.	Conical disc.	Double shell.	Double shell.	Conical disc.	Double shell.	Double shell.
	Material of pistons	Cast steel.	Cast steel. **	Cast steel.	Cast steel.	Cast steel.	Cast steel.	Cast steel.	Composition.	Composition.	Cast steel.	Composition.	Composition.
	Thickness (or depth) of piston at centre	2¾ 2¾ 2¾	2 2½ 4½‡	2¾ 2¾	2 2½ 2½	2⅝ 2⅝ 2⅝	2¼ 2¼ 2¼	2¼ 2¼ 2¼	11 11	8 .... 10½	1¼ 1½ 1½	11¾ 11¾	13 15
	Thickness (or depth) of piston at rim	1½ 1½ 1½	1⅜ 1⅜ 7½	1⅜ 1¼	1¼ 1⅜ 1⅜	1½ 1½ 1½	1⅜ 1⅜ 1⅜	1⅜ 1⅜ 1⅜	9½ 9½	10½ 10½	⅞ 1 1	7¾ 7¾	15 15
	Breadth of packing ring	1¼ 1¼ 1¼	1¼ 1¼ 1¼	4½ 4½	1¼ 1¼ 1¼	1¼ 1¼ 1¼	1¼ 1¼ 1¼	1¼ 1¼ 1¼	7 7	2 2	1¼ 1¼ 1¼	5¾ 5¾	12 12
Piston rod	Material of piston rods	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.
	Diameter of piston rods	7½	7¼	7¼	8½	6	3¾	3¾	7	H. P. 4½ L. P. 3¼ (Two.)	3½	7½ 7¼	H. P. 8 L. P. 6½ (Two.)
	Maximum thrust on rod per square inch, at B. P	4,108	4,631	3,500	3,296	5,139	5,529	5,529	3,240	3,067	6,037	3,852	4,100
Guides	Material of piston rod guides; of slipper	Cast steel. W. metal.	Forged steel. W. metal.	Cast iron. W. metal.	Cast steel. W. metal.	Cast iron. W. metal.	Cast steel. W. metal.	Cast steel. M. metal.††	Cast iron. W. metal.	Cast iron. Composition.	Cast steel. W. metal.	Cast iron. Composition.	Cast iron. Composition.
	Area of slipper for one cylinder	520	607	521	621	432	186	186	336	360	105	238	483
	Maximum thrust per square inch of surface	83.4	81.2	71.5	77.7	100	78.8	78.8	84.2	35.1	126.1	182.6	102.4
Connecting rod	Material of connecting rod	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Wrought iron.	Wrought iron.	Wrought iron.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Wrought iron.
	Length of connecting rod, between centres	86	72	72	84	86	64	64	108	66	45	108	90
	Diameter of connecting rod: necks; middle	6⅝ 7	6¼ 7¼	6¼ 7 ..	6 7 ..	5¾ 6¾	3¾ 4½	3¾ 4½	7 8 7½	4¼ 5¾ 4¾	3 4	8 9 9¼	8 8½ 9
	Maximum thrust on rod per square inch, at B. P	5,830	6,433	4,534	6,826	5,744	5,684	5,684	3,320	3,704	8,432	3,307	4,237
Cross-head	Number of cross-head journals, one cylinder	Two.	Two.	Two.	One.	Two.	Two.	Two.	One.	One.	One.	Two.	One.
	Dimensions of cross-head journals	9 dia. × 10 long.	8½ dia. × 8 long.	7½ dia. × 8 long.	8½ dia. × 14 long.	7¼ dia. × 8½ long.	4½ dia. × 5¾ long.	4½ dia. × 5¾ long.	8 dia. × 11 long.	5½ dia. × 8 long.	4½ dia. × 6 long.	7½ dia. × 8 long.	10 dia. × 14 long.
	Maximum thrust on journals per square inch, at B. P	1,038	1,452	1,243	1,623	1,214	1,202	1,202	1,452	1,152	2,205	1,378	1,513
Crank shaft	Material of crank shaft	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Forged steel.	Wrought iron.
	Type of crank shaft	Built up.	Solid 3 sections.	Solid forged.	Solid forged.	Built up.	Solid forged.	Built up.	Built up.	Solid forged.	Solid forged.	Built up.	Built up.
	Diameter of crank pin; length	15 16¾	15 16	12¾ 18⅛	15½ 15⅞	13 15	9 10	9 10	13 18	9 12	7¾ 9	14½ 19	15 18
	Diameter of crank pin holes: forward; intermediate; after	7½ 7 6½	7 7 7	4½ .. 4½	7 7 7	6 5 4	3 3 3	3 3 3	0 0	3 3	4 2 2	0 0	0 0
	Diameter of crank shaft	14½	14¼	12¾	15	13	9	9	13	9	7¾	14½	16
	Diameter of crank shaft holes: forward; intermediate; after.	7½ 7 6½	7 7 7	4½ .. 4½	7 7 7	6 5 4	3 3 3	3 3 3	0 0	3 3	4 2 2	0 0	0 0
	Total length of main journals	121¾	114	87½	114	104½	71	71	84	55	68	94	156
	Maximum pressure on crank pin per sq. in., at B. P.‡‡	743	823	646	787	766	695	695	546	470	850	601	784
	Maximum pressure on shaft journals per sq. in., at B. P.‡‡	243	365	190	308	328	240	240	246	144	293	260	254
	Thickness of crank webs: forward; intermediate; after	9½ 10½ 10½	10½ 10½ 10½	8 .. 8	11¼ 11¼ 11¼	8 9 10	6½ 6½ 6½	6½ 6½ 7¼	9 9	5½ 5½	5¾ 5¾ 5¾	10½ 10½	9 9
Line shaft	Diameter of line shaft	13¾	13¼	12¼	14	12½	9	9	13½	9	7¼	14½	16
	Diameter of hole in line shaft	6	7	4½	8	5	3	3	0	3	3	0	0
Thrust	Number of thrust collars	12	11	11	11	12	9	9	13	8	11	15	19
	Width of thrust collars	1⅜	1⅝	1½	1⅝	1⅜	1¼	1¼	1⅝	1¼	1¼	1⅝	1¼
	Space between thrust collars	1⅞	2⅛	2½	2⅛	1⅞	1⅝	1⅝	1¾	1⅜	1¼	1¾	1½
	Thrust surface, one shaft	1,206	1,135	958	1,210	1,206.8	499.6	499.6	909.3	384	518	988	2,615
	Thrust surface per I. H. P. (designed)	....	....	.2554	.2688	.2839	.2940	.2940	.3910	.3490	.3237	.3952	.7471

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* First figure is for steam at outboard or top end; second for steam at inboard or bottom end; third for exhaust, mean of both ends. † Modified gear. ‡ L. P., double shell. ** L. P., of composition. †† Magnolia metal. ‡‡ At half stroke.

TABLE II.—AUXILIARIES AND BOILERS.

	Name of vessel	Philadelphia.	San Francisco.	Charleston.	Baltimore.	Newark.	Yorktown.	Concord.	Dolphin.	Petrel.	Vesuvius.	Chicago.	Boston.
Condenser	Total length of condenser	14 ft. 1½ ins.	12 ft. 9½ ins.	15 ft. 4 ins.	11 ft. 7 ins.	13 ft. 11¾ ins.	8 ft. 11 ins.	8 ft. 11 ins.	11 ft. 6 ins.	12 ft. 5 ins.	8 ft. 3 ins.	14 ft. 7 ins.	Two 12 ft. 4½ ins.
	Diameter of shell inside	5 ft. 8 ins.	6 ft. 6 ins.	5 ft. 7½ ins.	5 ft. 4 ins. ×7 ft. 4 ins.	5 ft. 8 ins.	4 ft. 5½ ins.	4 ft. 5½ ins.	6 ft. 10 ins. ×3 ft. 7 ins.	3 ft. 6 ins.	4 ft. 4½ ins.	9 ft. 11 ins. ×2 ft. 8½ ins.	3 ft. 9½ ins. ×8 ft. 6 ins.
	Material and thickness of shell	Composition. ⅛	Composition. ⅛	Copper. ¼	Composition. ⅛	Composition. ⅛	Rolled brass. ¼	Rolled brass. ¼	Cast iron. 1	Rolled brass. ¼	Composition. ⅛	Cast iron. 1¼	Cast iron. 1
	Length of tubes exposed	12 ft.	9 ft. 11 9/16 ins.	13 ft. 4½ ins.	7 ft. 6 ins.	12 ft.	7 ft.	7 ft.	9 ft.	11 ft.	6 ft. 6 ins.	12 ft.	6 ft. 6 ins.
	Diameter of tubes outside	⅝	⅝	⅝	¾	⅝	⅝	⅝	¾	⅝	⅝	⅝	⅝
	Number of tubes in one condenser	3,440	4,453	3,092	4,256	3,186	2,080	2.151	2,264	1,370	2,124	1,668	4,140
	Cooling surface in one condenser, in sq. ft	6,755	7,259	6,751	6,184.3	6,254	2,380	2,463	4,000	2,466	2,259	4,587	4,403
Air pump	Type of air pump	V. S. A. independent.	H. S. A. independent.	V. S. A. independent.	H. D. A. dependent.	V. S. A. independent.	V. S. A. independent.	V. S. A. Davidson.	V. S. A. Blake.	Incl'd S. A. dependent.	V. S. A. dependent.	V. S. A. Blake.	H. D. A. independent
	Diameter of air-pump steam cylinder: H. P.; L. P.	11 18	12 19	10 (Two).		11 18	11 18	14 (One).	22 (One).			22 (One).	18 (One).
	Diameter of air-pump water cylinder	24 (Two).	26 (Two).	24 (Two).	28	24 (Two).	24	18 (Two).	24½ (Two).	14	14 (Two).	24½ (Two).	18 (One).
	Stroke of air-pump	18	18	16	42	18	12	12	21	18	6 3/16	21	S. C. 30½, W. C. 31½
	Material of pump rod	Composition.	Aluminum bronze.	Aluminum bronze.	Muntz metal.	Composition.	Steel, comp. cased.	Wrought iron. in trunk.	Phosphor bronze.	Rolled phos. bronze.	Rolled brass.	Phosphor bronze.	Iron, brass cased.
	Diameter of pump rod	2½	2½	3½	4	2½	2¼	1¾	3	2½	1¾	3	3
Circulating pump	Type of circulating pump	Centrifugal.	Centrifugal.	Centrifugal.	Centrifugal.	Centrifugal.	V. S. A. independent.	H. D. A. Davidson.	H. D. A. Blake.	Centrifugal.	Centrifugal.	H. D. A. Blake.	H. D. A. independe
	Diameter of circulating pump steam cylinder	11	H. P., 7½. L. P., 12	9	11	10		14	22	8	10	22	18
	Diameter of circulating pump water cylinder						20	18	26			26	18
	Stroke of circulating pump	6 (S. C.)	6 (S. C.)	8 (S. C.)	12 (S. C.)	6 (S. C.)	12	12	24	6 (S. C.)	8 (S. C.)	24	30½
	Diameter of wheel or runner	2 ft. 8 ins.	3 ft.	2 ft. 8 ins.	3 ft. 6 ins.	2 ft. 8 ins.				2 ft.	2 ft. 8 ins.		
	Diameter of suction	15	17	14	17	15	11	11	14	10	14	14	16
Propeller	Type of propeller	Modified Griffiths.	Modified Griffiths.	Modified Griffiths.	Modified Griffiths.	Modified Griffiths.	Modified Griffiths.	Modified Griffiths.	Hirsch.	Modified Griffiths.	Modified Griffiths.	Hirsch.	Hirsch.
	Material of propeller	Manganese bronze.	Manganese bronze.	Manganese bronze.	Manganese bronze.	Manganese bronze.	Manganese bronze.	Manganese bronze.	Cast iron.	Manganese bronze.	Manganese bronze.	Cast iron.	Cast iron.
	Diameter of propeller	14 ft. 6 ins.	13 ft. 6 ins.	14 ft.	14 ft. 6 ins.	14 ft. 6 ins.	10 ft. 6 ins.	10 ft. 6 ins.	14 ft. 3 ins.	9 ft. 9 ins.	7 ft. 9 ins.	15 ft. 6 ins.	17 ft.
	Mean pitch of propeller	20 ft. 4½ ins.	18 ft. 9 ins.	17 ft. 6 ins.	20 ft.	18 ft. 11¾ ins.	12 ft. 6 ins.	13 ft. 2½ ins.	24 ft. 1 in.	12 ft. 3 ins.	9 ft. 4½ ins.	24 ft. 7 ins.	24 ft. 4½ ins.
	Number of blades	Three.	Three.	Three.	Three.	Three.	Three.	Three.	Four.	Three.	Three.	Four.	Four.
	Helicoidal area, sq. ft.	57.17	57.59	54.75	57.17	52.77	25.42	26.52	72.14	23.55	16	77.93	95.66
	Projected area, sq. ft	43.86	44.55	43.35	45	40	20.6	21.45	48.56	17.75	12.45	54.64	69.84
	Greatest width of blade, at radius	53¼ 3 ft. 11 ins.	55¾ 3 ft. 3 ins.	49⅝ 4 ft.	53¼ 3 ft. 11 ins.	48 3 ft. 11 ins.	29½ 3 ft. 3 ins.	29½ 3 ft. 3 ins.	40¾ 3 ft. 7 ins.	28 2 ft. 4 ins.	23 1 ft. 11 ins.	40½ 3 ft. 3 ins.	46 4 ft. 6½ ins.
	Thickness of blade at hub	6¼	5¾	5¾	6¼	6¼	4	4	7	3	3½	7½	9
	Diameter of hub	3 ft. 11½ ins.	3 ft. 11 ins.	3 ft. 6 ins.	3 ft. 11½ ins.	3 ft. 11½ ins.	2 ft. 6½ ins.	2 ft. 6½ ins.	2 ft. 5 ins.	1 ft. 4 ins.	1 ft. 4 ins.	2 ft. 4 ins.	2 ft. 8 ins.
	Length of hub	3 ft. 1½ ins.	3 ft. 1 in.	2 ft. 5 ins.	3 ft. 1½ ins.	3 ft. 1½ ins.	1 ft. 10⅞ ins.	1 ft. 10⅞ ins.	2 ft. 5 ins.	1 ft. 10 ins.	1 ft. 10 ins.	2 ft. 8½ ins.	3 ft. 2½ ins.
	Ratio of diameter to pitch	1 to 1.406	1 to 1.39	1 to 1.25	1 to 1.38	1 to 1.308	1 to 1.19	1 to 1.257	1 to 1.689	1 to 1.28	1 to 1.21	1 to 1.58	1 to 1.42
	Ratio of blade disc area to immersed mid-section	1 to 2.470	1 to 2.692	1 to 2.405	1 to 2.474	1 to 2.350	1 to 2.516	1 to 2.542	1 to 2.232	1 to 3.83	1 to 2.03	1 to 2.095	1 to 2.766
Boilers	Number and type of main boilers	Four D. E. Scotch.	Four D. E. Scotch.	Six S. E. Low.	Four D. E. Scotch.	Four D. E. Scotch.	Four S. E. Low.	Four S. E. Low.	2 D. E., 2 S. E., Scotch.	Two S. E. Low.	Four S. E. Low.	5 D. E., 2 S. E. Cylind.	Eight S. E. Scotch.
	Material of boilers	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.
	Length of double-ended boilers; single-ended boilers	19 ft. 10⅞ ins. ..	19 ft. 2 ins. ..	.. 19 ft. 3 ins.	17 ft. 8 ins. ..	19 ft. 4⅞ ins. ..	.. 17 ft. 9 ins.	.. 17 ft. 9 ins.	18 ft. 3 ins. 9 ft. 6 ins.	.. 18 ft. 4 ins.	.. 19 ft. 8 ins.	24 ft. 6 ins. 11 ft. 10 ins.	.. 9 ft. 9 ins.
	Diameter of double-ended boilers; single-ended biloers	14 ft. ..	14 ft. 8 ins. ..	F'd., 11 ft. Aft., 11 ft. 6 ins.	14 ft. 8 ins. ..	13 ft. 6 ins. ..	.. 9 ft. 9 ins.	.. 9 ft. 9 ins.	11 ft. 11 ft.	.. 8 ft. 8 ins.	.. 8 ft. 11 ins.	9 ft. 9 ft.	.. 11 ft. 8 ins.
	Thickness of shell: D. E. boilers; S. E. boilers	1⅛ ..	1 1/32 ..	.. 41/64	1 1/32 ..	1 3/32 ..	.. 13/16	.. 13/16	¾ ¾	.. ⅝	.. ¾	⅝ ⅝	.. ⅞
Furnaces	Total number and type of furnaces	32 Corrugated.	24 Corrugated.	18 Addison ring.	32 Corrugated.	24 Corrugated.	12 Corrugated.	12 Corrugated.	12 Addison ring.	4 Corrugated.	12 Corrugated.	12 External.	16 Addison ring.
	Number of furnaces in each D. E. boiler; S. E. boiler	Eight. ..	Six. ..	.. Three.	Eight. ..	Six. ..	.. Three.	.. Three.	Four. Two.	.. Two.	.. Three.	Two. One.	.. Two.
	Least internal diameter of furnace	36	42	F'd, 42½. Aft., 44½.	36	43	37	37	40	40	34		48
	Length of grate	6 ft. 6 ins.	6 ft. 7 ins.	6 ft. 1½ ins.	6 ft. 10 ins.	6 ft.	5 ft. 9 ins.	5 ft. 9 ins.	6 ft. 9 ins.	7 ft	5 ft. 9 ins.	7 ft.	7 ft.
	Total grate surface, in sq. ft. [main boilers]	624	553	421.2	656	540	220	220	270	93.2	195	672	400
	Depth of combustion chamber	4 ft. 6 ins.	2 ft. 5 ins.	4 ft. 6 ins.	2 ft. 1¾ in.	4 ft. 6 ins.	3 ft. 9 ins.	3 ft. 9 ins.	2 ft 6 ins.	9 ins.	4 ft. 6 ins.*	D. E., 3 ft. S. E., 2 ft. 9⅓ ins.	1 ft. 11 ins.
Tubes	Material of tubes	Wrought iron.	Wrought iron.	Wrought iron.	Wrought iron.	Wrought iron.	Wrought iron.	Wrought iron.	Drawn brass.	Wrought iron.	Wrought iron.	Wrought iron.	Drawn brass.
	Outside diameter of tubes	2¼	2¼	3	2¼	2½	2¼	2¼	2¾	2¾	2¼	3¼	2¾
	Length between tube sheets	7 ft. 7⅞ ins.	6 ft. 9 ins.	7 ft. 1⅝ ins.	6 ft. 4 ins.	7 ft. 6 ins.	6 ft. 11 ins.	6 ft. 11 ins.	6 ft. 1⅝ in.	7 ft. 10 ins.	8 ft	8 ft. 10 ins.	6 ft. 9 ins.
	Total number of ordinary tubes	3,184	3,308	1,956	2,848	2,416	1,480	1,480	1.200	352	1,672	2,304	1,776
	Total number of stay tubes	672	896	342	944	528	272	272	108	44	264		
	Thickness of ordinary tubes	No. 12 B. W. G.	No. 12 B. W. G.	No. 10 B. W. G.	No. 8 B. W. G.	No. 12 B. W. G.	No. 11 B. W. G.	No. 11 B. W. G.	No. 11 B. W. G.	No. 11 B. W. G.	No. 12 B. W. G.	No. 10 B. W. G.	No. 11 B. W. G.
	Thickness of stay tubes	No. 8 B. W. G.	No. 6 B. W. G.	5/16	¼	No. 7 B. W. G.	No. 6 B. W. G.	No. 6 B. W. G.	No. 6 B. W. G.	5/16	No. 8 B. W. G.		
	Pitch of tubes: horizontal; vertical	3⅜ 3¼	3½ 3¼	Staggered: 4⅛	3½ 3¼	3¾ 3½	3⅜ 3¼	3⅜ 3¼	3⅞ 3¾	4⅛ 3 15/16	3 2¾	4¼ 4½	4 3¾
	Cross area through tubes, in sq. ft.	85.3	91.56	90.12	86.72	81.8	37.68	37.68	44.80	15.4	32.64	114	60.32
Thickness	Thickness of tube sheets	9/16	¾	11/16	13/16	9/16	9/16	9/16	F. C. ¾ B. C. ⅝	½	9/16	F. C. ¾ B. C. ⅝	F. C. ¾ B. C. 9/16
	Thickness of front head above tube sheet	⅞	1 1/32	⅞	⅞	⅞	¾	¾	D. E. ⅝ S. E. ¾	½	9/16	¾	¾
	Thickness of combustion chamber sheets	9/16	½	35/64	½	9/16	9/16	9/16	9/16	7/16	9/16	9/16	9/16
	Thickness of furnace crowns	½	½	½	½	37/64	½	½	½	7/16	½	⅝	½
Braces	Material and number of braces above tubes	Steel. 18	Steel. 9	Steel. 18	Steel. 32	Steel. 20	Steel. 15	Steel. 15	Steel. 21	Steel. 7	Steel. 10	Steel 8	Steel. 16
	Diameter of braces above tubes	2½	2¼ and 2½.	2⅛	2	2¼	2¼	2¼	1¾	2¼	2½	2⅛	2 and 2¼.
Heating surface	Total heating surface, in sq. ft	20,457.68	19,657.56	15,147	16,674.7	16,739.8	8,091.88	8,209.6	6,550.8	2,796	8,081.2	19,844.96	10,146.4
Water space	Area of water surface, sq. ft.; water level above tubes, ins.	948 6¾	960 8	1,185 8½	932 6	1,009.6 6½	606 10	612 8	523.2 10	176 6	640 6	1,196.2 10	1,109.4 8
Steam space	Total steam room, in cu. ft. [main boilers]	2,348	2,689.6	3,075	3,012	2,053.8	1,194	1,311	1,261.8	594	1.348	2,365.4	1,892.7
Ratios	Steam space to grate area	3.76	4.86	7.3	4.59	3.8	6	5.96	4.67	6.37	6.90	3.94	4.73
	Heating surface to grate surface	32.78	35.55	35.96	25.42	30.99	36.78	37.3	24.26	30	46.06	33.14	25.3
	Grate surface to cross area through tubes	7.3	6.06	4.67	7.56	6.6	5.8	5.8	6.02	6.05	6.0	5.26	6.62
	Grate surface to cross area through smoke-pipe	8.72	8.19	4.63	7.45	8.14	5.7	5.7	6.54	5.86	8.27	5.97	7.07
	Capacity of furnaces and combustion chambers to G. S.	3.35	3.40	4.15	2.97	3.72	2.95	2.95	3.85	2.48	4.36	4.48	4.36
Weights	Tons weight of one boiler with water: D. E.; S. E.	87.9 ..	91.23 ..	For'd, 52 84. Aft, 58.15	8* ..	80.12 ..	.. 41.1	.. 41.66	54.0 27.3	.. 24.64	.. 35.50	44.8* 21.5*	.. 32.97
	Total weight in boiler comp't per 100 square feet of H. S	2.39 tons.	2.279 tons.	2.198 tons.	2.94 tons.	2.37 tons.	2.35 tons.	2.68 tons.	3.10 tons.	2.365 tons.	1.890 tons.	2.70 tons.	3.23 tons

* Approximate.

TABLE III.—SPEED TRIALS.

	Name of vessel	Philadelphia.	San Francisco.	Charleston.	Baltimore.	Newark.	Yorktown.	Concord.	Dolphin.	Petrel.	Vesuvius.	Chicago.	Boston.
	Duration of trial	Four hours.	Four hours.	Four hours.	Four hours.	Four hours.	Four hours.	Four hours.	Six hours.	Four hours.	Eighteen minutes.	Six hours.	Six hours.
	Speed developed, in knots	19.67	19.52	18.2*	20.095*	19.0*	16.14*	15.8	15.5	11.55*	21.13	15.13	15.8*
Hull	Mean displacement of hull, tons	4,325	4,088	3,557	4,500	3,980	1,703	1,740	1,413	855	771	4,546	3,000
	Length between perpendiculars	315 ft.	300 ft.	300 ft.	315 ft.	310 ft. 10 ins.	228 ft.	228 ft.	240 ft.	175 ft.	246 ft. 3 ins.	315 ft.	270 ft.
	Beam at L. W. L	48 ft. 7 ins.	49 ft. 1¾ ins.	46 ft. 2 ins.	48 ft. 6 ins.	49 ft. 2 ins.	36 ft.	36 ft.	32 ft.	31 ft.	26 ft. 5 ins.	48 ft. 2½ ins.	42 ft.
	Ratio of length to breadth	6.49 to 1	6.308 to 1	6.49 to 1	6.495 to 1	6.305 to 1.	6.33 to 1	6.33 to 1	7.5 to 1.	5.66 to 1	9.32 to 1	6.53 to 1	6.43 to 1
	Mean draft	19 ft. 2½ ins.	18 ft. 9 ins.	17 ft. 10½ ins.	18 ft. 10½ ins.	18 ft. 3 ins.	14 ft.	14 ft. 1¼ ins.	13 ft. 9½ ins.	11 ft. 2 ins.	9 ft. 6 ins.	19 ft. 1 in.	16 ft. 9½ ins.
	Area of L. W. L. plane, sq. ft	10,875	10,467	9,700	10,875	10,500	5,765	5,765	4,717	3,852	4,574†	11,072	8,346
	Area of immersed midship section, sq. ft	815	770	741	816.64	775	435.3	439.8	338	286	192	790	628
	Coefficient of fineness of displacement	.515	.509	.51	.515	.510	.497	.502	.5015	.494	.403	.547	.546
	Wetted surface—Kirk's analysis	20,100	19,006	17,806.6	20,585	19,110	11,428	11,510	10,250	6,768	7,545	21,862	16,220
	I. H. P. per 100 square feet of wetted surface	43.85	50.41	37.43	48.89	46.41	32.31	29.6	21.98	15.4	52.98	23.25	42.9
Steam pressure	Steam at boilers, per gauge	159.8	135.3	91.44	Gauges out of order.	161.8	150.5	164.3	87.08	89.9	153	87.3	87.6
	Steam at engines, per gauge. S.; P	151.2 154.0	126.2 128.4	85.9 86.3	125.1 123.44	156.1 152.6	142.3 144.8	159.9 159.6	85.21	79	149.8 149.1	85.7 84.0	85.†
	Steam at first receiver, absolute: S.; P	57.61 56.5	55.1 58.1	23.84 23.52	62.2 59.28	57.4 59.7	68.7 72.7	79.5 77.0	28.04	28	72.5 77.5	39.6 39.7	37.†
	Steam at second receiver, absolute: S.; P	24.52 24.3	19.25 18.25	......	20.4 21.75	16.8 16.6	20.6 19.7	29. 28.5	......	......	28.17	......	......
Engines	Revolutions of main engines per minute: S.; P	119.58 119.55	125.79 123.83	115.35 113.95	116.42 116.08	127.4 126.7	157.98 155.94	151.5 153.3	74.15	126.7	267.7 270.0	69.3 69.3	72.3
	Piston speed in feet per minute: S.; P	797.2 797.0	754.78 743.65	692.10 683.7	814.94 812.56	849 844.4	789.9 779.7	757.3 766.7	593.2	606.8	892.3 900.0	658.3 658.3	506.1
	Position of throttle: S.; P	Wide. Wide.	.55 .55	Wide. Wide.	Wide. 7.5 holes.	.8 .8	Wide. Wide.	Wide. Wide.	Wide.	Wide.	Wide. Wide.	Wide. Wide.	Wide.
	Cut-off in main cylinders, stbd.: H. P.; I. P.; L. P	.6 .72 .74	.69 .69 .69	.72 .67	.69 .77 .77	.75 .76 .62	.76 .76 .76	.79 .78 .78	.536 .602	.65 .65	.75 .74 .66	.66 .66	.66 .35
	Cut-off in main cylinders, port: H. P.; I. P.; L. P	.58 .74 .75	.69 .69 .70	.72 .67	.70 .77 .77	.72 .72 .65	.76 .76 .76	.79 .78 .78			.75 .74 .66	.66 .66	
	Mean pressure in main cylinders, stbd.: H. P.; I. P.; L. P	61.95 21.3 8.91	51.37 25.3 9.93	42.20 14.55	50.17 21.87 9.52	58.8 25 15.0	57.67 32.8 10.02	53.8 30.4 15.36	41.41 12.95	51.3 13.4	58.2 33 15.03	33.95 15.20	40. 16.37
	Mean pressure in main cylinders, port: H. P.; I. P.; L. P	57.73 19.9 9.98	46.45 26.8 10.64	44.75 14.96	52.29 22.49 9.84	53.0 24 13.6	55.65 35.5 10.72	53.1 28.7 15.0			63.1 28 15.5	32.79 12.38	14.9
	Aggregate equivalent mean pressure on L. P. piston: S.; P	30.51 30.1	30.32 30.68	26.54 26.83	28.23 29.20	38.23 35.28	33.61 34.94	37.26 36.1	24.96	28.3	40.3 39.7	26.51* 23.30	26.2
Vacuum	Vacuum in condenser in inches of mercury: S.; P	24.3 24.67	25.7 26.1	26.17 26.06	24.5 24.3	25.9 25.6	24.84 25.02	24.1 24	25.5	23.0	24.6 24.3	24.7 24.6	24.3
	Cooling surface per I. H. P., sq. ft	1.540	1.494	2.085	1.256	1.411	1.403	1.446	1.775	2.360	1.13	1.804	2.330
Air pump	Revolutions of air-pump engines per minute: S.; P	105.3 118.2	197 131	134.7 135.2	116.42 116.08	105 125	123 120.5	102.8 101.8	30.71	126.7	267.7 270.0	44.5 43.6	26.†
	Displacement of air-pump pistons per I. H. P. per min., cu. ft.	.238	.365	.405	.677	.244	.229	.214	.199	.194	.148	.295	.128
	I. H. P. of air-pump engines: S.; P	31.56 33.32	66.48 41.23	21.98 20.87	......	29.9 31.6	60.88‡ 57.91‡	13.73‡ 13.59‡	41.2‡	......	......	38.0† 37.2†	81.†
Circulating pump	Revolutions of circulating-pump engines per minute: S.; P	274.8 234.3	199.7 201.25	343.3 313.9	177 177	208 209	See air pump	See air pump	See air pump	282	264.5	See air pump	See air pump.
	I. H. P. of circulating-pump engines: S.; P	30.27 24.7	14.36 15.07	51.75 41.56	23.21 23.21	15.06 15.14				4.27	19.5†		
Blowers	Revolutions of blowers per minute	516	478	486	566	665	751 763	497.6	......	660	830	500	550
	Number and aggregate I. H. P. of blowers	Eight. 87.57	Eight. 110.67	Four. 75.57	Eight. 110.86	Eight. 117.32	Four. 52.03	Four. 34.7	Four. 60†	Two. 35	Four. 54.2†	Eight 100	Six. 60.†
	Diameter of blower fans	4 ft. 6 ins.	3 ft. 4 ins.	3 ft. 4 ins.	4 ft. 6 ins.	4 ft. 6 ins.	4 ft. 6 ins.	4 ft. 6 ins.	6 ft.	4 ft. 6 ins.	4 ft. 6 ins.	4 ft. 2 ins.	4 ft. 2 ins.
	Air pressure in fire-rooms in inches of water	1.49	2.02	1.77	2.085	2.23	1.25	2.29§	Fire-rooms open.	4.4	2.0	2.1	1.7§
I. H. P	I. H. P. of H. P. cylinder: S.; P	1,645.10 1,560.47	1,590.06 1,427.92	1,426.61 1,395.45	1,682.65 1,749.17	1,353.5 1,223.0	519.76 495.41	464.7 464.0	1,021.95	504.2	570.0 624.8	1,068.9 1,031.32	1,395.6
	I. H. P. of I. P. cylinder: S.; P	1,352.17 1,325.24	1,603.63 1,700.43	......	1,514.10 1,555.69	1,355.2 1,316.6	588.78 631.89	524.7 502.0	......	......	673.6 576.5	......	......
	I. H. P. of L. P. cylinder: S.; P	1,249.73 1,400.46	1,594.39 1,664.29	1,732.92 1,761.08	1,625.62 1,680.61	1,759.6 1,574.3	471.16 498.28	688.7 670.1	1,122.22	496	732.7 718.7	1,445.5 1,178.24	982.0 1,076.8
	I. H. P. of each main engine: S.; P	4,247.00 4,286.17	4,788.08 4,792.64	3,159.53 3,156.53	4,845.59 4,985.48	4,468.3 4,113.9	1,579.7 1,625.58	1,678.1 1,636.1	2,144.17	1,000.2	1,976.3 1,920.0	2,514.4 2,209.56	3,454.5
	I. H. P. of main engines, air and circulating pumps	8,653.02	9,717.86	6,452.22	9,877.49	8,674.07	3,324.37	3,341.6	2,185.57	1,001.27	3,915.8	4,799.1	3,535.5
	I. H. P. of feed pumps	34.48	42.85	45.84	28.81	53	16.15	17.6	7.75	3.57	24†	See air pump.	See air pump.
	I. H. P. of all other auxiliaries	127.26	152.22	168.10	181.34	141.5	52.03	45.3	60.0	36.94	58.0	284.6	241.1
	Aggregate I. H. P. of all machinery	8,811.76	9,912.93	6,666.16	10,064.42	8,868.5	3,392.55	3,404.5	2,253.12	1,044.78	3,997.8	5,083.7	3,776.6
Temperatures	Temperature of fire room, forward; aft	117.6	114.1	92.3	93 93	66.3	58.7 72.5	91.4	87.3 97.1	96.6	97	105 120	130 125
	Temperature of engine room, forward; aft	87.6	100.7 94.8	107.5 90.1	70 73	86.01 70.3	71 81.2	89.3	85.86	93	90	97.3 110	127
	Temperature of injection water	63.3	63.7	65.3	56	45	40.4	36	67	77	63	45	73
	Temperature of discharge: S.; P	113.3 111.4	101.2 99.3	107.4 106.4	100 97	103.3 75.3	97.2 88.0	105	96.3	116	90	104 107.3	116
	Temperature of feed: S.; P	145.4 134.3	109.5 103.1	116.4 115.1	129 131	112.4 78.3	91 102.6	139.9	111.19	119	122	105 102	124.5
Thrust	Indicated thrust in pounds: S.; P	57,481 58,017	66,988.5 68,115.4	51,651.2 52,236.2	63,890 65,920	61,026 56,489	26,398 27,521	27,692 26,670	38,736	21,142	26,021 25,364.	48,910 43,092	64,773.
	Indicated thrust per square inch of thrust surface	47.66 48.11	59.02 60.91	53.9 54.5	61.2 63.15	47.98 44.41	72.88 75.98	52.06 50.1	43.72	55	50.2 49.5	49.5 43.6	21.8
Propeller	Indicated thrust per square foot of hel. area of propeller	1,006.7 1,016.1	1,163.19 1,182.76	943.4 954.08	1,117.6 1,153.0	1,156.3 1,070.4	1,037.5 1,083.	1,044 1,005.6	531.1	898.1	1,626 1,602	627.4 552.4	677.5
	Slip of propeller per cent: S.; P	18.2 18.2	15.45	8	18.62 18.38	20.3 19.87	17.19 16.07	19.9 20.8	11.67	24.5	14.8	9.9 9.9	20.4
Coal	Coal used per hour, pounds	26,351.4	......	20,096*	30,353**	21,590.5	......	9,402.1	4,926.	4,275	......	13,395	11,770
	Coal used per hour per square foot of grate	12.2	......	46.07	44.9	40.0	......	42.7	18.25	42.5	......	19.9	29.4
	Coal used per hour per square foot of heating surface	1.288	......	1.290	1.767	1.290	......	1.145	.752	1.528	......	.673	1.16
	Coal used per hour per I. H. P. (all machinery)	2.99	......	3.01	3.15	2.43	......	2.76	2.19	4.15	......	2.63	3.11
Ratios	Total heating surface per I. H. P.	2.321	2.03	2.33	1.707	1.887	2.385	2.412	2.91	2.676	2.216	3.91	2.72
	I. H. P. per square foot of grate surface	4.126	17.46	15.28	14.89	16.42	15.42	15.47	8.34	12.56	20.5	7.56	9.45
	I. H. P. per ton weight in engine compartment ‖	27.63	22.07	19.76	21.61	25.48	24.10	24.9	11.758	17.15	31.12	11.5	......
	I. H. P. per ton weight in boiler compartment ‖	17.555	21.32	16.88	20.51	21.36	16.72	15.47	11.71	15.8	23.58	9.6	11.5
	I. H. P. per ton weight propelling machinery and water	10.45	11.25	9.72	10.53	12.08	10.46	9.92	5.867	8.21	16.8	4.86	5.32
	I. H. P. per ton weight all machinery, spare gear and tools	10.08	10.84	9.15	10.12	11.62	10.23	9.59	......	7.54	16.05	......	5.29
	Ratio of cooling surface to total heating surface	1 to 1.514	1 to 1.386	1 to 1.129	1 to 1.360	1 to 1.337	1 to 1.7	1 to 1.931	1 to 1.64	1 to 1.134	1 to 1.988	1 to 2.167	1 to 1.15
	Capacity of steam room in revolutions; in seconds §§	38.6 19.3	33.77 16.2	33.71 17.6	33.98 17.6	32.6 15.45	59.8 23.0	63.02 24.8	33.5 27.13	21.5 11.7	108.2 24.1	17.08 14.8	25.75 21.40

* Patent log.

† Approximate.

‡ Air, circulating and bilge pumps.

§ Closed ash-pits.

Estimated.

‖ Auxiliary boiler not used.

‡‡ Including water.

§§ At given cut off.

26786 N—III.—Face page 66.

THE BURSTING OF THE MAIN STEAM PIPE IN THE U. S. S. CONCORD.

The official report of the board appointed to investigate the circumstances attending the unfortunate accident, resulting in the loss of two lives, which occurred on board the U. S. S. *Concord* in June, 1891, was not made public in time for its insertion in General Information Series No. X. This report, which has since been published, presents some features of peculiar interest in connection with the phenomenon of "water-hammer", to which the board attributed the occurrence of the accident.

The boilers of the *Concord* are of the straightway cylindrical type, four in number, arranged in pairs in two separate compartments, with athwartship fire-rooms, one forward of the two forward boilers and one abaft the two after boilers; each boiler has a main stop-valve connected to its front, with an athwartship pipe for each pair of boilers connecting the main stop-valves; the main steam pipe from the forward boilers (which was the pipe that burst) runs aft along the starboard side of the boilers for a distance of about 40 feet, from the stop-valve of the starboard forward boiler to a communicating valve in the after fire-room; from this valve a curved section, forming one leg of a Y, leads to the separator situated just forward of the engine-room bulkhead, the other leg of the Y leading from the communicating valve for the after boilers, situated on the port side close to and in connection with the stop-valve of the port after boiler; the two communicating valves referred to serve to connect with the engines either the forward or after boilers at will; in the present instance the port communicating valve may be thrown out consideration. It may readily be seen that when the main stop-valves of the forward boilers are open, the boiler pressure will exist in that portion of the main steam pipe in which failure occurred, whether the communicating valve be open or closed. It should be stated that, in addition to the main stop-valves, each boiler has an auxiliary stop-valve by means of which communication may be established through the auxiliary steam pipe. With these explanations it is believed that the following extracts from the report of the board of investigation will be readily understood:

> The vessel had been steaming with the after group of boilers (C and D), and the surplus steam had been blown into the forward boilers (A and B) through the hydrokineter for the purpose of heating the water in those boilers. At 8:18, a. m., fires were started in the furnaces of boilers A and B. Steam formed in boiler A at 10:23, a. m., and in boiler B at 10:40, a. m. The main stop-valves connecting boilers A and B were then opened, their steam gauges examined and found to indicate the same pressure, and the fires were then spread. At 11:28, a. m., the four boilers were all connected by opening the auxiliary stop-valves on boilers A and B. The steam gauges on the forward boilers (A and B) showed a pressure of 110 pounds, which agreed substantially with the pressure shown by the gauges on the after boilers (C and D). * * * At 11:35, while the communicating valve was being slowly opened, and before more than half a turn of the valve-stem had been given, the accident occurred. The forward fire-room was suddenly filled with steam * * *. Shortly after 2, p. m., it was possible to enter the forward fire-room for the first time. * * * Exam-

ination showed that the main steam pipe had burst about 3 feet forward of where it passes through the bulkhead between the two fire-rooms.

* * * A careful examination by the Board of the rent in the pipe after its removal from the vessel shows that it followed along the brazing of the seam for about 26 inches, and then at the after end took a turn of about 45 degrees, tearing through the solid copper of the pipe for a distance of 5 inches; at the forward end it had torn forward into the solid copper at about the same angle to a distance of three-quarters of an inch. This rent was opened out to a width of about 7 inches in the widest place. At about the widest part of the rent a ⅜-inch pipe-plug had been screwed in. This plug was not found, and whether it was of iron or brass is not known. It had been put in to stop a small leak which had been discovered after the main steam pipe had been put in the vessel, and when steam was first raised by the contractors on the boilers. Six inches abaft the large rent was a smaller one in the brazed seam, about 3 inches long by one-fourth of an inch in width.

* * * In pursuance of the Board's decision to thoroughly examine and test the injured pipe, it was taken to the navy-yard, and the part that remained sound (4 feet, 8 inches long) was prepared to be tested by hydraulic pressure. A ⅜-inch screw plug was screwed into the seam so that the same initial point of weakness might be furnished as was in the original pipe. * * * Pressure was furnished by the accumulator of a riveting machine in the boiler shop of the Steam Engineering Department. At 600 pounds, the ⅜-inch screw plug began to leak. At the same pressure, the rivets in the end flange, put in by the contractors, began to leak. At 1,200 pounds, one of the ⅞-inch bolts holding on the ⅝-inch steel plate ends broke, letting one of the gaskets out. No further application of pressure could be had, and the pipe was examined. The ⅝-inch steel heads were bulged ½ inch; the ends of the pipe, which had been annealed, increased about ⅜ inch in diameter; the contractors' flange was cracked and spoiled; but the brazed seam did not start. For the purposes of this Board, this test is sufficient to establish the integrity of the brazing of what was left of the pipe after the disaster. It will be seen that the seam which was the suspected part stood uninjured at 7½ times the working pressure. It appeared in testimony that 300 and 170 pounds had been applied to this pipe in water pressure, and that 168 pounds of steam had been used. After observing this test and weighing the evidence, we do not believe that the broken pipe gave out at 110 pounds steam pressure, which it will be remembered was the pressure registered on the gauges at the time of the disaster. We are then compelled to look for some other cause. After careful examination of drawings and their verification and the weighing of evidence, we arrive at the opinion that the disaster was caused by "water hammering", or, as it is called, "water ramming."

The reasons for arriving at this conclusion are as follows: The pipe leading from boilers A and B (the forward ones), of which the broken one is a part, was not provided with drainage outfit because it was assumed that being a level pipe it would drain into the boilers. This might be so if the ship were trimmed by the head, but not so if by the stern; besides, it is an 8-inch pipe, and the boiler stop-valves are only 6 inches in diameter. If on a level, and the stop-valves were cracked off their seats or leaked a little, 1 inch of water might stand in the pipe. The stop-valves of boilers A and B are arranged as check-valves, intended to open, after the stem is withdrawn, by the excess of pressure. This pipe may have been filled or partly filled with water. A curved pipe extends from the intermediate stop-valve connecting the forward with the after group of boilers to the separator. When the after group of boilers are in use and the forward ones are not, this pipe is a dead pipe, and the end towards the valve, being lower than the other, may fill with water. As in the pipe first described, there being no means of drainage, there is no chance to satisfy the attendant whether the pipe does or does not contain water. The conditions necessary to set up water-ramming are a pipe (the longer the more effective for destruction), steam, and water. The pipe was there; when the communicating valve was opened, the steam was there; although we can not prove the presence of water we can not account for this disaster under any other hypothesis.

Attention is called by the Board to the fact that the $\frac{3}{8}$-inch plug in the steam pipe had been put in without the knowledge of the inspector. With regard to the phenomenon of "water-hammer", it may be said that its occurrence is usually ascribed to the collapse by condensation of bubbles of steam passing through colder water, causing a mass of water to rush in with considerable momentum to fill the vacuum so created; the sudden arrest of the mass of water so set in motion gives a ramming effect similar in many cases to that obtained in a pipe full of running water by the sudden closing of a spigot. That the necessary conditions for the occurrence of the phenomenon existed at the time of the accident, the report of the Board very clearly indicates, but it is of course impossible to ascertain what additional strain beyond the steam pressure was necessary to start the rupture. The strength of the brazed joint in the uninjured portion of the pipe was shown by the Board, not only by the hydraulic test described, but by subsequent tensile tests of specimens from the joint, to be fully equal to that of the solid metal, but it is to be noted that the brazing in the portion that gave way had already given indication of faultiness, as evidenced by the insertion of the screw plug; how far the strength of the pipe was reduced at this point can be only a matter of conjecture. It is probable that had the pipe been of uniform strength throughout, the water-ramming effect would not have been sufficient to cause failure; that, however, a pressure was developed considerably in excess of the ordinary steam pressure would appear to be established, and the resulting accident calls attention, as was pointed out by the Board, to the importance of providing suitable drainage arrangements for all pipes affording lodgment places for condensed steam.

DETERIORATION OF CONDENSER TUBES IN THE U. S. S. BALTIMORE.

A singular instance of deterioration of condenser tubes was reported from the U. S. S. *Baltimore* in January of the present year. The condenser of this vessel is of English design, and fitted, according to the custom very generally adhered to until recently in vessels of the English navy, for the passage of the exhaust steam inside the tubes and of the condensing water outside, an arrangement the reverse of American practice, as well as of the practice of the English mercantile marine. The vacuum obtained in the condenser having been for some time impaired, whilst the *Baltimore* was actively employed in cruising, on account of the accumulation of large quantities of mud on the salt-water side of the tubes, advantage was taken of the opportunity afforded during the stay of the ship at Mare Island to remove the tubes in order to clean out the mud. In the process of taking out the tubes it was incidentally discovered that some of them were very brittle, although there was nothing in their outside appearance to indicate that deterioration had taken place. Further examination disclosed the fact that all of the tubes were in the same condition, and could be broken in the hand with ease, seeming to have completely lost their elasticity. The tubes of the auxiliary condenser, similarly arranged for the passage of steam on the inside, were found to be in still worse condition than those of the main condenser, about one-half of the tubes having their lower ends, near the point of admission of the circulating water, eaten away to such an extent that this condenser was practically transformed into a jet condenser. A board of survey was ordered, with the result that all the tubes of both condensers were replaced by new ones.

An investigation into the causes of the deterioration was made by Assistant Engineer A. M. Hunt, U. S. Navy, whose report was indorsed by the Board as a portion of its finding. Before quoting the principal portions of this interesting report, it should be explained that the condenser tubes of the *Baltimore* are arranged in two nests, an upper and a lower; the circulating water is admitted to the space outside the tubes at one end of the lower nest, and at the opposite end passes up to the space outside the tubes of the upper nest, after traversing which it is discharged outboard. The deposits of mud outside the tubes of each nest were greatest at the ends furthest from the point of admission of the circulating water, extending at these ends to the top of the chamber in each case. In both nests of tubes, the deterioration was found to be greatest at the ends nearest the point of admission of the circulating water, whilst the tubes were least affected where protected by the deposits of mud. The following extracts are made from Mr. Hunt's report:

> I first examined a large number of tubes, removing the adhering mud and grease. In all cases I found the tin coating on the inside of the tubes bright and intact. The outside surfaces were dull in appearance, and rubbing them down with canvas I found the tin coating entirely gone in spots. Some tubes had hardly any tin on the outside surfaces. Wherever the tin coating remained, on scraping it off I found yellow metal underneath. On scraping down where the tin coating was gone, the metal was coppery. The coppery metal was so brittle as to be easily broken in the fingers. Its fracture was dull reddish brown in color, and examination under the microscope showed it to be porous or spongy. The yellow metal was tough and apparently unchanged. The lines of demarcation between the two colors were clearly defined, with no shading of one into the other.
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> Chemical analysis revealed the following facts. They are not the results of single analysis, but the averages of repeated determinations. The reddish brown metal proved to be copper of a purity from 99 to 100 per cent., and showing not even a trace of zinc. The yellowish metal was brass of a composition of copper, 60 per cent., zinc, 40 per cent., with a trace of lead, and samples taken as close to the red metal as possible showed no material variation from these figures. The mud was found to contain only inert substances. Loss by ignition (water and organic matter), 12.1 per cent.; silica, 40.4 per cent.; alumina, 32.9 per cent.; lime, 4.6 per cent.; salt, 6.3 per cent.; total, 96.3 per cent. The remaining 3.7 per cent. was probably carbonic acid (CO_2) combined with the lime. I found small pieces of shell in the mud, and calculating the lime as calcium carbonate gives a total percentage of 99.9. The mud contained a certain amount of uncombined silica as sand, and was quite gritty.
>
> To determine the original composition of the brass in the tubes, I took samples from several spare ones, said to be of the same lot as at first put in. Their average

analysis gave: copper, 60 per cent.; zinc, 39 per cent.; no tin; lead, $\frac{25}{100}$ per cent.; iron, mere trace. Scrapings of the tin coating on one of the spare tubes gave: loss by washing in ether (grease and oil), 4 per cent.; tin, 22 per cent.; lead, 65 per cent.; copper, 4 per cent.; zinc, 2 per cent.; unaccounted for, 3 per cent. Part of the unaccounted for material was probably oxygen combined with a portion of the lead. The copper and zinc undoubtedly came from particles of the brass mixed with the scrapings of the coating.

The action by which the zinc was removed from the metal of the tubes evidently progressed from the outside of the tubes toward the inside, as evidenced by the unbroken tin coating inside, and the fact that numerous samples were found where the outside metal was changed to copper with an interior shell remaining brass. As the change started and worked from the salt water side of the tubes, any theory with regard to the action being the effect of the fresh water or grease is untenable. As the mud found in the condenser contains only inert substances, no chemical action could have taken place with it as an agent. The complete removal of zinc from the alloy seems to indicate a galvanic action, which is always accomplished by the destruction of the electro-positive element. The sharp lines of demarcation of the altered portions, and the way in which the alteration has spread from the centres, giving some specimens a blotched appearance when polished, would indicate that the galvanic action had taken place between different parts of the same tube, and not between the metal of the tube and some outside body.

The following is, to my mind, the only rational explanation of the action which has taken place that can be deduced from the facts as above cited. To have accumulated so much mud in the condensers, a very large quantity of it must have been swept through, and, containing a considerable quantity of grit, it would abrade the tinned surface of the tubes. This abrasion would be rendered more rapid, owing to the fact that the tin of the coating contained such a large percentage of lead as to be quite soft. The fact that the tubes were most affected and the tin coating most removed at points where the currents of water moved transversely to the tubes, and that the tubes were least affected where the deposited mud protected them from the abrading action, renders this explanation of the manner of the removal of the tin coating extremely probable. When the tin coating had been removed at any one point, there was then left a brass surface exposed, adjacent to and intimately connected with a tin (tin-lead alloy) surface, and covered by an exciting liquid, sea water. That under such circumstances galvanic action would take place between the two metals can not be questioned, and one element or the other of the local battery so formed would undoubtedly be attacked. To prove the existence of a current in a couple similar to the above, I immersed two sections of condenser tubing, from one of which the tin coating had been removed, in salt water, and found a very perceptible current, using a galvanometer that was not at all sensitive. Zinc is the most electro-positive of all the common metals, and would in such a couple be the metal destroyed, and that it was destroyed in the altered metal of the tubes is shown by the analysis. As soon as the zinc was removed from a portion of the brass, pure copper was left behind in a spongy state, and it formed a couple with the adjacent brass, and the action spread from it as a centre. If the copper so left were not spongy enough to absorb water, the action would probably have ceased after the surface had been thus copper-plated, but being spongy it enabled the action to progress through the thickness of the tube.

To prove that copper will absorb water, I weighed a piece, after thoroughly cleaning it, and then placed it in distilled water for one-half hour. I then removed it, and after carefully drying the outside of it, reweighed. I found it had absorbed 2.8 per cent. of water by weight, or 24.6 per cent. of the volume of a solid piece of copper of the same weight as the spongy sample used. If the above theory is correct, had the tin coating on the tubes remained intact, no such action could have taken place; and I am also of the opinion that had the tubes not been tinned at all, they would not have been affected.

ENGINES.

THE VIBRATION OF VESSELS.

The most important contribution to marine engineering literature during the past year was the instructive and eminently practical paper read by Mr. A. F. Yarrow before the Institution of Naval Architects, April 7, 1892, "On Balancing Marine Engines, and the Vibration of Vessels", which, with the interesting experiments it describes, may be justly considered as the most valuable accession to the knowledge of this subject yet received. The paper is reproduced in full, with numerous illustrations, by both *Engineering* and *The Engineer*, in their issues of April 8, 1892. It will be sufficient here to give a general abstract embodying its salient features.

In modern vessels of high speed, requiring proportionately large power, the considerable vibrations set up by fast-running engines in steel hulls become of increasing importance with every additional requirement as to speed and power, and it is to the solution of the problem of so designing marine engines as to prevent these vibrations as far as possible that Mr. Yarrow's investigations have been directed. Throughout the experiments undertaken, material assistance was afforded by the use of Mr. Nesbitt's vibrometer, an ingenious instrument for recording the extent and character of vibrations. This consists essentially of a heavily weighted drum turned by clockwork about a vertical axis, and suspended by elastic connections from an overhead framework rising from a rigid base; the drum carries a sheet of paper after the manner of the ordinary indicator, and against this paper a pencil attached to a fixed standard lightly presses. This instrument being placed upon any portion of a vessel's deck the extent of vibration of which is to be determined, the rigid base will partake of whatever motion the deck itself may have, but the weighted drum, by virtue of its inertia and the elastic nature of its suspension, will be affected by rapid vertical vibrations only to an inappreciable extent; there will in consequence be a relative vertical motion between the pencil and the drum, which, combined with the rotation of the drum by clockwork, will result in the tracing of a zigzag diagram, inspection of which will afford information as to both the amplitude of the vibrations and the number per minute.

Mr. Yarrow states it to be his belief, as the result of a large number of experiments, that the vibration of screw steamers running in smooth water with propellers well immersed is mainly due to the forces produced by the unbalanced moving parts of the machinery, such as the pistons, piston-rods, valves, etc., except when it is due to bad workmanship or bad state of repair. In offering his grounds for this belief, he says:

> From our experiments we have overwhelming proof that the vibration in a torpedo boat is precisely the same in extent and character when the screw is on and the

vessel driven by it through the water, as it is when the boat is stationary and the engines simply revolving without doing work, the propeller being removed.

Referring to diagrams showing the vibration at different speeds with the screw on and at the same speeds with the screw removed, he says:

> Not only do these diagrams prove that the screw had nothing to do with the vibration, and that it was owing to the working of the machinery, but it will be seen how greatly our investigation is facilitated by these facts, because experiments can be carried out with a boat at rest, and we know that the same results as regards vibration will be found under ordinary working conditions.

The screw itself is often regarded as the main cause of vibration, and the screws of vessels are sometimes changed with a view of lessening vibration, but Mr. Yarrow very clearly points out that where such alterations are efficacious their success is due not to differences in the shape of the propellers, but indirectly to the alteration in the number of revolutions of the engines, thereby preventing their synchronizing with the natural vibrations of the ship. Interesting diagrams are exhibited showing the variation of vibration at different speeds and in passing from one speed to another, and the case of a torpedo boat is cited in which severe vibration occurred at 200, 400, 600, and 800 revolutions per minute, but did not exist at the intermediate speeds of 300, 500, and 700.

The problem of preventing, or at least greatly ameliorating, the vibrations due to the machinery becomes greatly simplified when it is shown that the action of the screw itself may be disregarded; there remains then only the effect of the unbalanced moving parts to be considered, and these are readily divided into two classes, those having rotary motion and those having reciprocating motion, the former of which, consisting of the crank, crank-pin, and a portion of the connecting-rod, can be balanced by means of rotating counterbalance weights in the usual way; so that the problem reduces itself to the balancing of the reciprocating parts, such as the piston, piston-rods, valves, etc. In dealing with this subject, Mr. Yarrow confines himself for simplicity to the consideration of the vertical inverted type of engine, though his methods may be readily modified to apply to any other type. As to the causes bringing about vibration through the action of the reciprocating parts, the following paragraph may be quoted:

> Let us consider exactly why an engine produces vibration. In an ordinary inverted engine the steam presses on the cylinder cover and on the piston, and from the piston the stress is transmitted to the bedplate. Now, during the first half of the down stroke the upward pressure on the cylinder cover is greater than the downward pressure on the bedplate to the extent of what is needed to set the reciprocating parts in motion, and this excess of upward over downward pressure lifts the engine bed and that portion of the hull to which it is attached. By a like train of reasoning it can be shown that during the latter half of the down stroke and the first half of the up stroke the tendency is to lower the engine bed; also that during the second half of the up stroke the tendency is to raise the engine bed. To sum this up in a few words, during the upper half of the revolution the engine tends to lift the vessel and during the lower half to depress it. The main principle which

governs the whole matter may be thus summed up: As no internal force can move the centre of gravity of a body it follows that any momentum generated by steam pressure in the moving parts such as the piston, etc., must be attended by an exactly equal momentum in the rest of the ship in the opposite direction.

In considering how to design engines to avoid vibration, the general principle is to be followed that to prevent the effect of the momentum of the moving parts being felt by the hull an equal momentum in an opposite direction must be produced. In the case of the single-cylinder inverted engine, if we have two eccentrics set opposite the crank, one on each side, at equal distances from the centre line through the cylinder, and these impart to two similar " bob-weights", together equal to the weight of the parts to be balanced, an up-and-down motion just equal to the stroke of the piston, the effect of the reciprocating parts (neglecting the valve and valve gear) in communicating vibration to the hull will be counteracted, except for the slight irregularity due to the obliquity of the connecting-rod and the obliquity of the bob-weight eccentric-rods. If we wish to place these weights at unequal distances from the centre line through the cylinder, they must be proportioned to vary in weight inversely as their distances from the centre line, the sum of the two weights remaining as before equal to the weight of the reciprocating parts. If we desire to reduce the stroke of the weights to obtain a convenient length of stroke, they must be increased in weight in the inverse proportion of the reduction of stroke. It is thus shown to be a simple matter to proportion the bob-weights, their stroke, and their position, to secure the most suitable design. If, instead of using bob-weights, rotary weights of equal amount should be employed having their centres of gravity in the same positions as the centres of the bob-weight eccentrics, the engine would still be balanced vertically, but would be unbalanced horizontally.

In extending the principle of balancing by means of bob-weights from the case of the single-cylinder engine to that of an engine of several cylinders with accompanying slide valves, Mr. Yarrow proceeds in the following manner: selecting the two most suitable positions on the shaft for fixing the bob-weight eccentrics, the weights and strokes of separate bob-weights are first ascertained for each piston and its reciprocating connections, and in the same way for each valve and its reciprocating connections; having dealt with all the reciprocating parts in this manner, if two uniform discs were constructed and fixed to the shaft at the positions selected for the bob-weight eccentrics, with the calculated weights pinned on, each opposite its own crank or valve-eccentric and at its proper distance from the axis of the shaft, the whole engine would be balanced vertically; upon each of the discs referred to, all the weights might be replaced by a single weight equal to the sum of all of them and having the same position of centre of gravity; these in turn might be replaced by larger or smaller weights, situated nearer the axis of the shaft or further from it as convenient, the weights being increased or diminished in the inverse ratio of the distances from the axis before and after the alteration; such a pair of weights fixed to the discs would

Vibration of Vessels. Mr. A. F. Yarrow's Experiments.

balance the whole engine vertically, but would set up side vibration; to avoid the latter and retain only the vertical effect, the rotating weights are replaced by bob-weights of equal amount, operated by eccentrics of the same throw as the rotating weights and set in the same angular position on the shaft.

It may be observed that the only inaccuracy involved in Mr. Yarrow's process lies in neglecting the obliquity of the connecting-rods and eccentric-rods, the effect of which is very small, so that in an engine balanced according to his method for the motion of reciprocating parts, and in the ordinary way by means of a revolving counterbalance for the motion of rotating parts, vibration should be practically eliminated. With regard to the treatment of the motion of the connecting-rod, which partakes of both a reciprocating and a rotary motion, the common plan is to consider one half of the rod as a rotating part and the other half as a reciprocating part; Mr. Yarrow prefers measuring the lateral movement of the centre of gravity of the rod, and considering that fraction of the weight as rotating which is represented by the ratio between this lateral movement and the double throw of the crank, and the remainder as a reciprocating weight. This plan is more logical and more exact, though the difference between the two results would commonly be slight.

A series of experiments to test the efficacy of bob-weights in preventing vibration were carried out by Mr. Yarrow and his assistants upon a first-class torpedo-boat, 130 feet long by 13½ feet beam, fitted with triple-expansion engines of about 1,100 I. H. P., and having a speed of 22 or 23 knots, carrying a load of 20 tons. The trials were made at the uniform engine speed of 248 revolutions per minute and under three different conditions:

(1) Without any balance weights whatever, as the engines of these torpedo-boats are usually constructed.

(2) With balance weights on the cranks only.

(3) With balance weights on cranks and bob-weights.

The amount of vertical vibration at the stern, as shown by vibrometer diagrams, was $\frac{27}{64}$ inch under the first condition, $\frac{20}{64}$ under the second, and but $\frac{7}{64}$ under the third. Mr. Yarrow states that this small remaining amount of vibration could have been, without doubt, practically avoided altogether by taking greater care in accurately ascertaining the weights of all moving parts. A series of very striking photographs are shown in connection with the account of these trials, in which the vibration under different conditions is very clearly evidenced by the appearance of the water near the hull. A pair of these are reproduced in the accompanying cuts (from *Engineering*, April 15, 1892). The ripples and nodes in the upper view are quite strongly marked, whilst in the lower the smooth water-line shows the almost complete absence of vibration. The difference was entirely due to the use of the weights in the second instance, the revolutions of the engines having been the same in both cases.

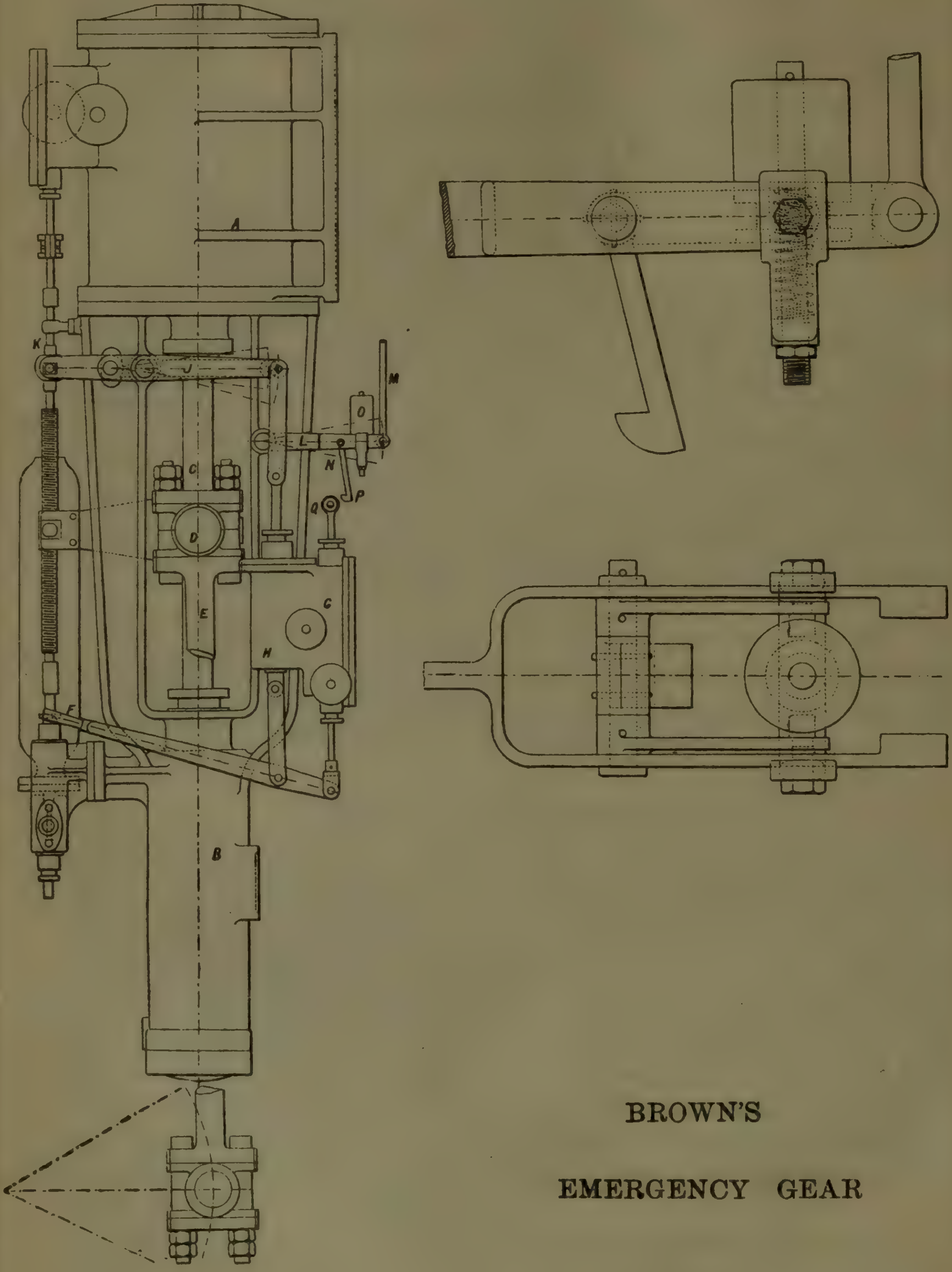
In connection with Mr. Yarrow's experiments, as well as with his general treatment of the subject of vibration, attention should be directed to the able article by Naval Constructor D. W. Taylor, U. S. N., upon "The Causes of the Vibrations of Screw Steamers", which appeared in the *Journal of the American Society of Naval Engineers*, February, 1891. Mr. Taylor's investigations are purely analytical in character, but are supplemented by simple graphical solutions. Whilst Mr. Yarrow's methods appear to possess the advantage of a greater simplicity, at least in the case of application to engines already built, if not always in the case of a new design, the same result is arrived at in both cases. Reducing the various unbalanced forces due to the motion of the reciprocating parts to a force and a couple, Mr. Taylor points out how each may be counteracted by a reciprocating weight driven by a crank or eccentric; in addition, he indicates how the forces to be balanced may be materially reduced by suitable arrangement of the cranks in the original design, and shows how under some conditions the two reciprocating weights required to produce balance may be reduced to a single weight suitably placed, suggesting further that with a design of air pump having separate vapor and water pistons the single reciprocating weight required to prevent vibration might be advantageously replaced by the plunger of the vapor pump.

It is of interest to note that the theoretical work of Mr. Taylor and the practical experiments of Mr. Yarrow are in perfect accord in indicating that the direct forces exerted by the propeller itself tending to cause vibration are as a rule inconsiderable.

BROWN'S EMERGENCY GEAR.

Reference was made in General Information Series, No. X., 1891, p. 85, in notes upon the repairs to the machinery of the Inman liner *City of Paris* after her unfortunate accident in March, 1890, to a controlling device fitted to her engines for the purpose of stopping them completely when the speed should exceed a fixed number of revolutions. Details of this device were not at the time available in print, but have since been published by *Engineering*, in the issue of July 10, 1891, from which the accompanying cuts are reproduced. The arrangement shown is that adopted in the S. S. *Scot*, built by Messrs. Denny & Co., Dumbarton, and, though differing in some particulars from that fitted in the *City of Paris*, is similar in principle.

The device is known as Brown's emergency gear, and is shown as fitted in connection with Brown's well-known steam and hydraulic starting and reversing gear. Referring to the diagrams, *A* is the steam cylinder and *B* the hydraulic cylinder of the ordinary gear, the two pistons being connected by the rod *C*, which carries a crosshead *D*, connected by the small link *E* to the gear for throwing over the main



BROWN'S

EMERGENCY GEAR

links; *F* is the starting lever of the reversing engine, operating a small slide valve in the case *G*, by means of which the admission and exhaust of steam in the auxiliary steam cylinder *H* is controlled; the piston of this auxiliary cylinder is connected by a link to the lever *J*, and this lever in turn is connected to the valve-rod *K*, upon which there are two valves, one for the steam cylinder *A* and the other for the hydraulic cylinder *B*. The emergency gear consists of a vibrating lever *L*, receiving motion from some reciprocating part of the main engine by means of the link *M*, and carrying a bell-crank *N*, one end of which carries the weight *O* supported by a spiral spring, whilst the other end terminates in the claw *P*. When the engines are in operation, the weight *O*, by virtue of its inertia, will at each revolution compress the spring as the lever *L* begins to rise, thus bringing the claw *P* near the pin *Q*, which is carried by the rod of the small slide valve in the case *G*; as the speed of the engines is increased, the compression of the spring effected by the weight *O* will become greater, and *P* will at each revolution approach still nearer to *Q*, until, when a certain speed is reached for which the spring may be set, the compression will become so great that the claw *P* will actually engage with the pin *Q*, and upon rising with the lever *L* will carry *Q* up with it, thus moving up the slide valve in the case *G* and admitting steam to the auxiliary cylinder *H* in the same manner as if the lever *F* had been put down by hand; the result is to throw the links into mid-position and at once completely stop the engine. Details of the bell-crank *N* are shown in plan and elevation in the side cuts, somewhat enlarged in scale in comparison with the general view.

The difference between the operation of this gear and that of any form of governing apparatus is at once apparent. It is not brought into play until a certain speed of revolution is attained, but when once thrown into operation by the engines themselves upon attaining the speed for which the spring is set, it acts at once in throwing the links to mid-position and so bringing the machinery to a standstill. It is especially designed to avoid the recurrence of such a disaster as that which befell the *City of Paris*.

BOILERS.

NEW TYPE OF FERRULE FOR FORCED DRAFT.

The frequent and serious failures of the boilers of recent British war vessels through leakage of the tubes, chiefly consequent upon the insufficient boiler power provided and the necessity of forcing the boilers beyond their capacity, has led to the introduction by the Admiralty of a boiler ferrule of special type, through the use of which improved results are reported as having been obtained in certain cases. The British service and engineering papers contain frequent references to the new device, of which the following extracts will serve to convey a general idea:

> There is now every probability that the great boiler difficulty, which has so long baffled all attempts to overcome it, will be effectually removed by the adoption of the new ferules. So successful were they on board the *Barracouta* that the engines, which formerly could not be pressed beyond 1,700 horses without excessive leaking of the boiler tubes, have been driven with safety to almost double their contract horse-power. They also acted satisfactorily when experimentally tested in the *Royal Sovereign,* and it is intended to fit them to the boilers of the *Vulcan* and the *Thunderer* on the arrival of the turret ship at Portsmouth. They are made of various metals, but the best results have been obtained from galvanized iron. The ferules extend for some distance in the tubes at the furnace end of the boiler, and are made with a deep flange which covers and protects the junction of the tubes with the tube plate where the leakage invariably occurs. But the novel feature connected with them is that the inner surface at the bend is grooved so as to allow of a space between the ferule and the tube. The new device subtracts from the air space, but, as danger of leakage is minimised, the difference is compensated for by increasing the fan draught. *London Times, May 13, 1892.*

> The trouble from leaky tubes has led to the introduction of a device for the protection of the tube ends from actual contact with the hot gases. This is the application of a protecting ferrule which has a trumpet-mouth end very much turned over. The ferrule is of considerable length, so that it projects inward some way beyond the tube plate. It also projects outward beyond the tube, and the bell, or trumpet-mouth end, turning back until its edge touches the tube plate, thus forms a shield to the contact joint between the tube and tube plate. Some of these ferrules were fitted in a few of the tubes of the *Royal Sovereign's* boilers with very good results, none of these tubes showing signs of leakage. Since then we have heard of a trial made with the *Barracouta,* which is pronounced a remarkable success. A number of trials have also been made at Chatham, and we hear it is "practically impossible to make tubes leak when these ferrules are fitted, however much the combustion may be forced." That we can believe, but after all such a device can only be of the nature of an expedient. It is a part of the design that there shall be an air-space under the turned-over ends of the ferrules, so that they get very little protection from the water in the boiler, supposing it to be there, and it would not be long before they burnt away; to say nothing of the chance of their falling out or being knocked out when sweeping tubes. In spite of this the plan may be of some value.
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> *Engineering, May 10, 1892.*

In connection with the subject of forced draft, for which these ferrules are designed to be used, it may be mentioned that, according to the *Naval and Military Record,* June 16, 1892, the Admiralty has decided, in continuation of the experiments with the Martin system of induced draft (described in General Information Series, No. X., 1891), to fit H. M. S. *Gossamer* with this system. It is reported that the vessel will be taken in hand for this alteration immediately after her return from the summer manoeuvres. The result of these experiments will be awaited with much interest.

LIQUID FUEL.

ITALIAN TORPEDO-BOAT EXPERIMENTS.

Brief notices from various sources were quoted in General Information Series, No. X., 1891, in relation to experiments by the Italian naval authorities in the use of liquid fuel, but only very meagre details of these important experiments are available through the service and engineering papers. The following extract, translated from *Pungalo*, a daily newspaper of Naples, is of some value as being one of the few articles upon this subject which has so far appeared in print:

Experiments were recently concluded at Spezia upon the Schichau torpedo-boat No. 104, of our navy, in the presence of a special commission, presided over by Admiral Sambuy, charged with determining whether liquid fuel, burned according to the system of Cavalier Cuniberti, a superior official of the naval engineering corps, possesses advantages over the use of coal.

It is known that the tendency in all modern vessels, and especially in vessels of war, is in the direction of increased speed, which can only be obtained by an enormous increase of the motive power, and this must be attended by the least possible increase in weight. From 300 kilogrammes per indicated horse-power, modern marine machinery, in the brief period of twenty years, has been reduced in weight to 27 kilogrammes per indicated horse-power, including the weights of engines, boilers, and propellers. But what is more marvelous, and gives an idea of the strides which private industry has made during this period, is that it has become possible to confine within a space as small as that afforded in the modern torpedo-boat the enormous motive force of 1,000 horse power. Nevertheless in this attainment the marine engineer has been obliged to utilize all the latest resources of mechanical science, employing triple-expansion engines to use the high pressure of twelve atmospheres furnished by the boilers, and in these latter making use of a blast of air in the furnaces so powerful that no little damage is done to the evaporative apparatus. Fashion leads even the more conservative to accept this state of things, and when a torpedo-boat returns to port after a few hours of full-speed steaming under forced draft, it is with a disabled boiler; serious leakages due to the cold air admitted into contact with the tube-plates, situated in the locomotive type of boiler directly in front of the furnace door, whenever the latter is opened for the introduction of coal, render it impossible to continue the navigation of the vessel; it is sought at first to disguise the gravity of the trouble, the tubes are reëxpanded, and after a second or third trial they have to be replaced at great expense and loss of time.

It is not we alone who are in this unfortunate condition, but other nations as well, whose navies are furnished with torpedo-boats from England and from Germany. In England at the present time there is a strong current of opinion among technical men against the use of forced draft, many preferring to give up large engine power and high speed rather than to run the risk in time of war of finding a large number of torpedo-boats disabled after a few days of service. Our Government, impressed with this fact, has acceded to the urgent requests of the Italian firms engaged in the construction of torpedo-boats after the model of Schichau of Elbing, in reducing the duration of full-power trials from three hours to one hour and a half, in order to diminish the injuries to the boilers resulting from the use of forced draft.

The scope of the experiments just made at Spezia is to ascertain whether these troubles can be avoided by the use of liquid fuel of any kind, whether consisting of oil, vegetable or mineral, of fatty residuals capable of liquefaction under the application of heat, or of refuse from the distillation of coal tar, schist oil, or petroleum, from whatever source it may be obtained. Engineer Cuniberti, who has recently been occupied with the latter fuel on board our men-of-war, with the result that in about two years his apparatus has been adopted in various naval vessels, including some of the largest we have, has sought until now in vain the means which England, Russia, and France have been so long fruitlessly seeking, of using this liquid combustible in torpedo-boats in a manner advantageous from both the engineering and the military point of view. It appears, however, that in the present system Engineer Cuniberti has at last discovered the solution of the problem, and since the Ministry has been so far impressed with this as to order to Spezia the high commission above mentioned, three members of which represent the three branches the most interested in the subject and the best competent to judge of it, those of construction, navigation, and machinery, it is evident that every point of importance and value is assured of thorough examination and consideration.

It can not be stated what conclusions have been reported to Rome by this commission, as up to the present time the greatest secrecy has been maintained with respect to all of the experiments, as a measure of precaution against other nations, but from what could be seen in the roadstead during the numerous and long trials at full power made by the commission on board torpedo-boat 104, it appears that combustion is accomplished without the production of smoke. This fact, of the truth of which there is ample ocular testimony, affords an incalculable advantage to the torpedo-boat, which, when painted the color of the sea, will be enabled to approach vessels closely without fear of having its presence betrayed by smoke, as would be the case at present, not only during daytime but at night also, through the general use of the electric search light, It appears, in addition, that whilst the commission has been enabled to go out every day without interruption, the boiler has not required the slightest repairing, nor has it been found necessary to expand the tubes, notwithstanding their exposure to the action of a flame much more intense than that of coal.

It is intended to prepare at once, at a location on the coast not far from Spezia, reservoirs for about 3,000,000 litres of this liquid residuum, which has the appearance of asphalt, and which is not in the slightest degree dangerous, being inflammable only at a high temperature.

It is probable that we are upon the eve of one of those radical changes in the operation of marine boilers, like that of the introduction of forced draft, but more successful, and the problem of the development of great motive power with economy of space and of weight is to have a solution, happily due to an Italian and an officer of our fleet.

The facts of chief importance to be gathered from this somewhat indefinite article are that the experiments proved successful in so far as being accomplished without failure of the boilers, that the liquid fuel used was not petroleum in the crude state, but petroleum residuum, and that with the apparatus employed combustion was effected without the formation of smoke. The residuum or refuse petroleum is the same fuel to which attention was called in the notes upon liquid fuel in General Information Series, No. X., 1891, in connection with the valuable paper by Captain W. V. Carmichael upon this subject. The reported absence of smoke during the trials of the Italian torpedo-boat is borne out by the similar experiences with the London and Pacific Company's steamship *Ewo* and with oil-burning locomotives on the Oroya Railroad of Peru, described in last year's notes.

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III.

NOTES ON ORDNANCE.

NOTES ON ORDNANCE.

The year's record of ordnance material, as embodied in these notes, is chiefly marked by the following features:

The continued failures of monster guns afloat, and the recognized increased efficiency of reduced calibres and weights for guns composing the main batteries of vessels;

The remarkable initial velocities developed by Canet by employing great lengths of bores;

Successful trial of the 67-ton gun mounts of the *Royal Sovereign*, and descriptions of some new service mounts;

The still further decrease in the calibres of the latest small arms adopted abroad;

Experiments with fish, dirigible, and gun torpedoes;

The growing popularity of smokeless powder, evidenced by its adopion in various services for use in both small arms and larger guns;

Experiments with high-explosives as bursting charges in shells;

Armor face hardening processes;

Practical tests of cellulose.

The year's notes on armor are embodied in an article on that subject, Chapter VII.

HIGH-POWER GUNS.

In endeavoring to secure the most powerful weapon afloat, the monster 110-ton guns have proved failures; or, as Capt. Wilmont, R. N., tersely terms them, "abnormal growths of peace which the rough tests of war will sweep away." That this is tacitly admitted in England is shown by the fact that no new guns of that type have been contracted for, and that the majority of large calibre guns manufactured during the past year were 13.5-inch, 67-ton, B. L. R. Italy, also, is confining herself to 68-ton guns, as the heaviest afloat, while the other leading powers are limiting themselves to still smaller calibres. This is most marked in Germany, where the 28^{cm} (11.02-inch) 35-calibre gun is accepted as the heaviest gun afloat of the future.

CHILE.

The first three Canet 24^{cm} (9.45 inch) 36-calibre, 31-ton guns, M/89, constructed for the battery of the *Capitan Prat*, have passed successful firing trials at the Hoc Polygone.

Following are the data of these trials:

GUN No. 1. DATE OF TRIAL, JANUARY 28, 1892.

Projectile.	Powder.		Initial velocity.	Pressure per square inch.	Remarks.
	Kind.	Weight.			
Pounds.		*Pounds.*	*f. s.*	*Tons.*	
335. 5	Brown prismatic ...	99	1548	5. 6	
335. 5	....do	148. 1	1935	10. 23	
376.	....do	200. 9	2188	16. 52	
378. 4	....do	200. 9	2217	16. 86	
377.	....do	200. 9	2208	16. 98	
377.	B. N$_1$	79. 2	1814	9. 04	
381.	....do	92. 4	2057	13. 55	
376.	....do	107. 8	2411	18. 51	Resistance proof.

GUN No. 2. DATE OF TRIAL, MARCH 11, 1892.

346. 5	Brown prismatic ...	99.	1509	5. 13	
334. 4	....do	149. 7	1912	10. 42	
334. 4	....do	149. 7	1902	9. 64	
376	....do	198. 1	2155	16. 39	
381	....do	198. 1	2155	16. 27	
376	....do	206. 9	2198	17. 25	Resistance proof.

GUN No. 3. DATE OF TRIAL, APRIL 8, 1892.

330	Brown prismatic ...	99	1519	4. 89	
331	....do	149. 6	1945	10. 42	
373	....do	198	2168	15. 86	
375	....do	198	2168	16. 39	
374	B. N$_1$	107. 8	2424	19. 25	Resistance proof.
374	....do	107. 8	2421	19. 41	Do.

ENGLAND.

During the year ending December 31, 1891, the following breech-loading guns were completed for the English navy:

Calibre.	Weight.	Number.
Inches.	*Tons.*	
16. 25	110½	1
13. 5	67	21
10.	29	10
9. 2	22	19
8.	14	1
6.	5	75
5.	40 cwt.	22
4.	26 cwt.	8

The total number of guns mounted and ready for service on that date, exclusive of rapid-fire and machine guns, was 1,623.

As yet, no *wire-wound* guns of large calibre have been introduced into service, and it is considered doubtful if they will be. Their lightness would bring dangerous strains on the mount, and the thinness of their walls would render them very vulnerable to small calibre rapid-fire and machine gun projectiles. Their introduction into service has, as yet, been limited to 12 pounder 6 cwt. field guns, replacing the service 12 pounder 8 cwt. piece, and during the army manoeuvers of 1891 these gave satisfactory results, using smokeless powder.

During the year, the English have continued to have trouble with their 110½ and 67-ton guns, and the public prints have contained numerous articles setting forth various causes and proposed remedies. Opinions are freely expressed that the life of even the 67-ton gun will not exceed 50 rounds with full charges, although it is considered to be 70 rounds, and that the successful gun of the future will not exceed 12 inches calibre and 50 tons weight. Some extremists consider a 10-inch 29-ton gun with a muzzle penetration of 21 inches wrought iron, as the most desirable heavy gun for service afloat.

110½-TON GUNS.

Twelve 110½-ton guns were originally contracted for from Armstrong's works, and as yet ten have been delivered; the other two are in course of construction. Two are mounted on board each of the three vessels, *Benbow*, *Victoria*, and *Sanspareil*, and it is intended that each vessel shall have two guns in reserve.

On account of the numerous failures of these guns and of their being changed from vessel to shop and *vice versa*, the following table, tracing the career of each, may be of interest:

Number of gun.	Originally mounted on board.	Replaced by gun No.	Present location.
1	*Benbow*	5	To be repaired.
2	do		*Benbow*.
3	Failed on trial		Reserved for experimental purposes.
4	*Victoria*	6	*Sanspareil*.
5	do	7	Strenghtened and to replace No. 1 on *Benbow*.
6	do		*Victoria*.
7	do		Do.
8	*Sanspareil*	9	Condemned.
9	do		*Sanspareil*.
10			Lately accepted.

13.5-INCH 67-TON GUNS.

The weakness of the 13.5-inch 67-ton Woolwich guns seems to be in the *Maitland liners*.

For the purpose of taking the erosive action of the powder gases and of being easily replaced, the A tubes of these guns were fitted with a thin lining of steel, made in two parts (Pl. I, p. 138, No. VIII). The rear section, or *Maitland liner* proper, extends from the breech plug seat to about half the length of the chase, and abuts the end of the front section, known as the ∝ tube, which screws into the muzzle.

The first trouble with these liners (page 125, No. X) was caused by their turning in the bore, and was probably due to the poor functioning of the rear locking ring; but this year cracks have developed which would seem to indicate that the enormous strains are too much for the *varying elasticity* principle employed, the liners being a neat fit and not being subjected to an *initial tension*, on which latter principle the remainder of the gun is constructed.

We understand that these *liners* have been discarded in the 13.5-inch guns constructed since 1888, the A tubes being now forged on a mandril. This is the case with the guns intended for the *Royal Sovereign*, one of which has replaced the defective gun of the *Anson*.

The following casualties are recorded during the past year:

BENBOW'S 110½-TON GUN.

The *Benbow* was fitted with guns Nos. 1 and 2, which were the first constructed. The *London Engineer* states that the rifling grooves of these guns were slightly shallower than those of the later guns for which the projectile bands were designed, and that therefore it would be unfair to tax the guns with weakness. Be this as it may, it is probable, following precedent, that the vessel would have been recommissioned at Malta had it not been discovered that defects had developed in her big guns.

Full charges have only been fired twice since June, 1888, and only reduced charges since November, 1888. Both guns are said to be defective, although no deflection is apparent to the eye looking through the bore. Gun No. 1 is soon to be replaced by No. 5, which has been strengthened since its failure on board the *Victoria*. Repairs have also been made to the mounts.

SANSPAREIL'S 110½-TON GUNS.

The guns now mounted on board this vessel are No. 4, which has been strengthened since its failure on board the *Victoria*, and No. 9.

It is stated in the public prints that these guns are not to be allowed to carry out the usual quarterly expenditure of ammunition.

VICTORIA'S 110½-TON GUNS.

This vessel is at present fitted with guns Nos. 6 and 7. The former has drooped slightly along the chase, near the muzzle, but is still regarded as serviceable.

Gun No. 7, which had not been fired for about two months, was discovered, last September, to have developed a slight crack in the A tube, near the muzzle. It was decided to cut off the damaged portion, and this has been done at Malta, 6 inches being removed. This decrease in the length of the bore naturally decreases the amount of powder that can be burned, and thus the initial velocity, and consequently the efficiency of the gun. Lord George Hamilton is quoted as stating that the probable reduction in velocity will be 25 f. s. from the original 2,100 f. s.

ANSON'S 13.5-INCH 67-TON GUN.

In October, 1891, during the regular annual inspection, it was discovered that the *Maitland liner* of one of the after barbette 13.5-inch guns was badly split.

The vessel was commissioned in May, 1889, and consequently this gun, No. 23, had been in service less than two and a half years. As the regulations require 16 rounds to be fired a year, only 4 of which are with full charges, only 36 rounds had been fired from this gun, less than 12 of which were with full charges. The life of this type of gun is considered to be 70 full charges.

The damage was serious enough to condemn the gun, which was removed from the vessel November 4, 1891, and replaced by one intended for the battery of the *Royal Sovereign*, in which the *Maitland liner* had been discarded.

HOWE'S 13.5-INCH 67-TON GUN.

Early in October, 1891, the 13.5 guns of the *Howe*, having fired their allotted number of rounds, were replaced by new ones.

After target practice with these, October 18, it was found that an opening of 0.1 inch had developed at the junction of the *Maitland liner* and the *a*-tube in one of the guns.

The gun is officially announced as "not damaged," but the evil effects which must surely result to the A-tube by the erosive effect of the powder gases acting through this opening, must render the gun practically unserviceable until the defect is repaired. The eventual removal of this gun for such repairs is anticipated.

BURSTING OF THE CORDELIA'S 6-INCH B. L. R. MARK II.

On June 29, 1891, during target practice on board H. M. S. *Cordelia*, a 6-inch B. L. R., Mark II, burst, killing two officers and four men and wounding twelve others. (See Pl. I.)

The gun was one of a lot of eighty-seven constructed of the Mark II type, in which the steel tube is reënforced by a wrought-iron jacket and breech hoops, and the chase is unhooped. Orders had been issued to chase-hoop these guns as they came in for repairs, and pending such changes, reduced charges were to be used in them. Published accounts, however, state that at the time of the accident the gun was loaded with a full charge of 34 pounds EXE powder and a fuzed common shell, the bursting charge of which was 7½ pounds. The gun had previously fired 200 rounds.

On the day of the accident six rounds had been fired, when, at the seventh round, the gun, which was in the port battery, burst explosively, as if by the force of some *high explosive.* The trunnions flew forward and aft, the breech block and carrier landed in the starboard gangway, all forward of the trunnions went overboard, and fragments went in all directions, cutting rigging aloft or passing down through the deck, the greatest force being exerted on the right side of the gun.

While these guns are recognized as being weak along the chase, the rupture in this case seems to have occurred near the combustion chamber, and the weight of opinion ascribes the cause of the accident to defects in the EXE powder employed. It is stated that when stored in ships' magazines under varying climatic influences, this powder has shown erratic results, equal charges producing pressures raising from 13 to 23 tons per square inch without apparent cause, and exerting its greatest pressure at varying distances along the bore. It is possible that in this instance some chemical change had taken place in this powder charge, causing its combustion to become so rapid that it partook of the qualities of a *high explosive.* All guns of a similar mark have been withdrawn from service and replaced by those of a more modern type.

FRANCE.

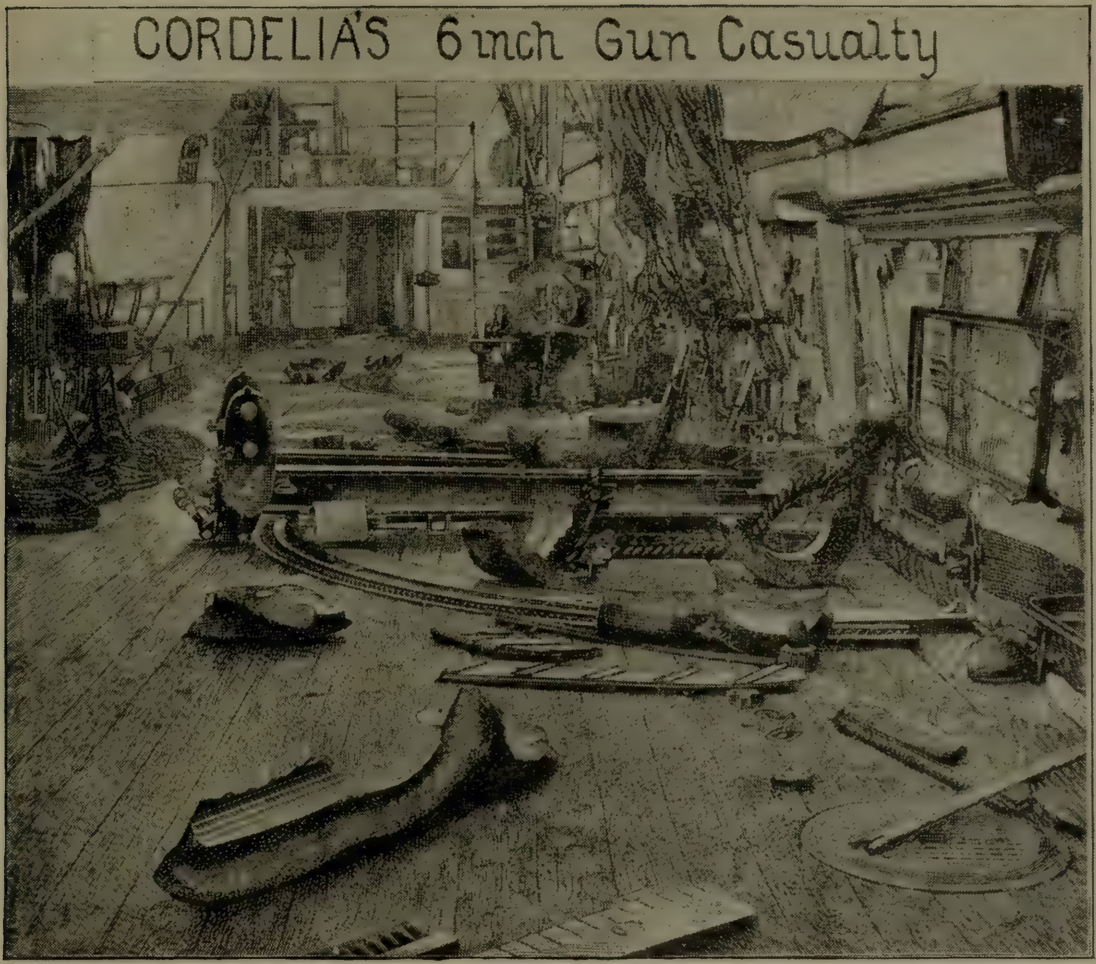
The tendency in France is to return to smaller calibres for their large high-power guns, recognizing that their efficiency depends more on the initial velocity imparted to the projectile than upon their calibre.

After considering the maximum thickness of armor adopted abroad, it was decided to introduce into service a gun of less calibre and weight than the 34^{cm} (13.39-inch) 58-ton gun, but of nearly equal power. Accordingly they have adopted, as the largest gun for the batteries of the ships in course of construction, a 30^{cm} (11.81-inch) 45 calibre gun, weighing about 45 tons, which shall impart an initial velocity of about 2,625 f. s. to a projectile weighing 625 pounds. The first gun of this type was satisfactorily tested at Ruelle in November, 1891, and it is the intention to build them, in future, of a length of 50 calibres.

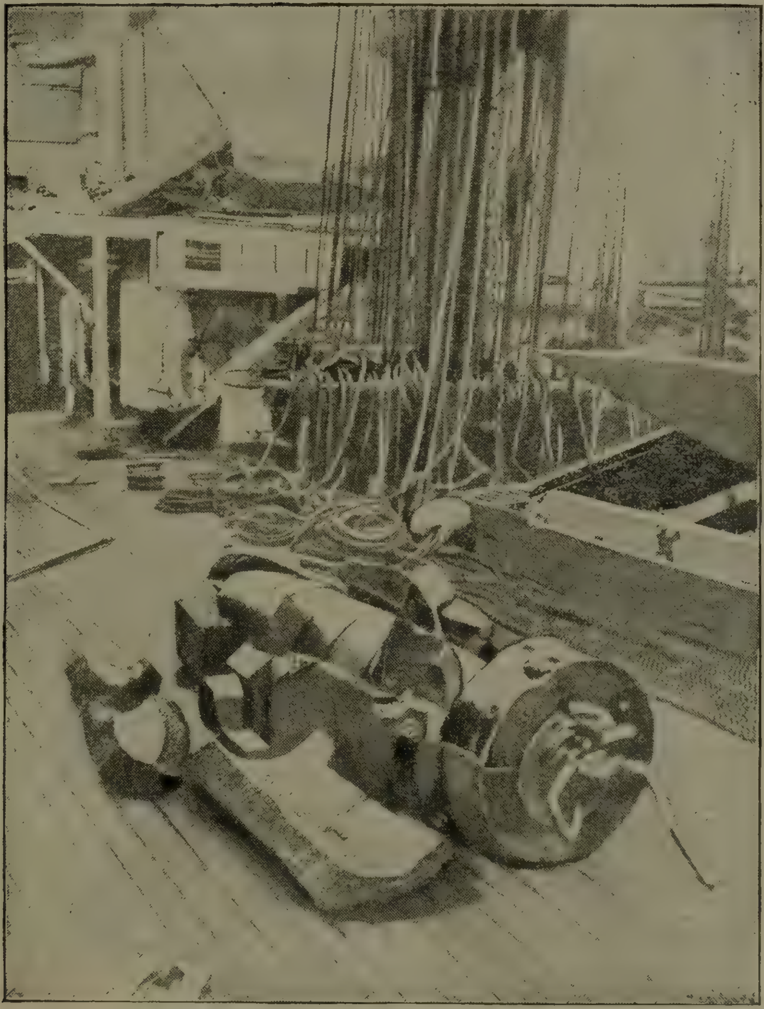
Instructions have also been given to prepare plans looking toward the substitution of these 30^{cm} guns for the 42^{cm} (16.54-inch) guns of the *Indomptable*, the mounts to allow for loading in any position.

Three of the nine 34^{cm}, L/42 calibres, M/87, B. L. R., building for new vessels, have been finished, but one *drooped* and required reconstruction. These guns are to give an initial velocity of not less than 2,460 f. s., using smokeless powder.

PLATE I.



AFTER THE ACCIDENT. [*London Graphic.*



GERMANY.

The policy in Germany is to reserve monster guns for coast-defense use, and to limit the heaviest guns afloat to the 28^{cm} (11.02-inch), 35-calibre, 35-ton Krupp guns, which compose the main batteries of the new battle ships.

During experimental firing at Essen in May, 1892, a range of 22,116 yards (12.56 miles), was attained with a 24^{cm} (9.45-inch) 40-calibre Krupp gun, and 18,210 yards (10.35 miles) with a 30^{cm} (11.8-inch) 35-calibre gun.

ITALY.

During the past year the Armstrong Works at Pozzuoli have been supplied by the Terni Steel Works with gun-forgings of domestic steel, which are considered of a better quality and more homogeneous than those of English material.

The largest guns now building for naval purposes are of 343^{mm} (13.5-inch) calibre, and 68 tons weight, the last one constructed being made entirely of domestic steel.

ANDREA DORIA'S 106-TON GUN.

One of the 106-ton Armstrong guns of the *Andrea Doria* was found, upon delivery, to be spotted and blistered in the powder chamber. It was landed at the Pozzuoli Works, and the defects being found to be 0.04 inch in depth, the tube was *linered* and the gun accepted. It is not, however, considered perfect on account of the quality of its metal, and is to be replaced by another gun from Armstrong's Works.

119-TON KRUPP GUNS.

The two 40^{cm} (15.75-inch), 31.7 calibre, 119-ton, Krupp guns, mentioned on page 127, No. X, have been mounted in a Gruson cupola fitted with Armstrong mounts, at Palmaria Island.

Firing trials were conducted May, 1891, for the purpose of testing the system, which was found to work well.

The charges varied from 682 to 759 pounds; projectiles, 1,980 pounds; the initial velocity developed with a 748-pound charge, being 1,837 f. s. Thirty-two rounds in all were fired, the guns being trained in elevation from $-5°$ to $+13°$.

The only defects recorded were due to injuries caused to the obturators, either during the translation movement of the breech blocks, or by the fouling residue of discharge.

BURSTING OF A 12 CM (4.72-INCH) GUN.

The bursting of a 12^{cm} (4.72-inch) breech-loading gun at Via Reggio is not attributed to any defect in the gun, but to the premature action of an experimental delayed-action fuze, which exploded a gun-cotton-charged shell in the bore, wrecking the piece.

JAPAN.

The last two of the three 32^{cm} (12.6-inch), 40-calibre, 65-ton, Canet breech-loading guns, constructed for the Japanese coast-defense vessels, have been finished and have passed very successful trials. While the tests were not as severe as that of gun No. I (page 128, No. X), in regard to the number of rounds fired, still both guns were subjected to greater chamber pressures, and both gave higher initial velocities, without injury to the guns or mounts.

An initial velocity of 2,386 f. s. was obtained during the thirteenth round fired from gun No. II, using BN smokeless powder, with a chamber pressure of 16.15 tons per square inch.

Following are the data of the trials:

GUN NO. II. TESTED JULY, 1891.

Number of round.	Kind of powder.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Chamber pressure.
		Pounds.	*Pounds.*	*f. s.*	*Tons per sq. in.*
1	Hex. Brown Prism. P. B. S	264	734	1715	4.95
2	....do	352	749	2004	7.73
3	....do	352	760	2002	8.53
4	....do	353	758	1996	8.53
5	....do	529	992	2263	15.93
6	....do	529	994	2264	15.92
7	....do	529	992	2264	15.09
8	....do	529	995	2264	16.15
9	....do	529	995	2271	17.34
10	....do	562	994	2354	18.14
11	BN	297	994	2199	13.22
12	....do	308	992	2209	15.32
13	....do	317	993	2386	16.15

GUN NO. III. TESTED OCTOBER 2, 1891.

1	Hex. Prism. Brown, P. B. S	264	750.2	1670	5.15
2	....do	352	755.7	1978	9.25
3	....do	528	997.7	2260	17.38
4	....do	528	995.5	2250	17.92
5	....do	528	988.9	2260	17.31
6	....do	556.6	993.3	2345	17.72

No casualties are recorded, and the breech mechanisms and mounts functioned satisfactorily.

As an illustration of the fact that the efficiency of a gun depends more upon the velocity imparted to the projectile than to the calibre of the gun, a comparison of the energy and penetration developed at the last round fired with gun No. II is here made with those of the Armstrong 16.25-inch, 110½-ton, and Krupp 15.75-inch, 119-ton guns, when using service charges:

Maker.	Calibre.	Weight of gun.	Weight of projectile.	Muzzle velocity.	Chamber pressure.	Total energy.	Energy per ton of gun.	Muzzle penetration, wrought iron.
	Inches.	*Tons.*	*Pounds.*	*f. s.*	*Tons per sq. in.*	*f. t.*	*f. t.*	*Inches.*
Armstrong	16.25	110½	1800	2148	19.5	57,570	521	37.98
Krupp	15.75	119	2028.2	1804	14.7	45,756	384.5	30.9
Canet	12.6	65	993	2386	16.15	39,187	602.9	31.93

The Japanese Government has lately contracted with Schneider & Co. for six 27^{cm} (10.63-inch), 50-calibre guns and mounts for coast-defense purposes. The contract was awarded in competition with other European firms.

NORWAY.

On September 18, 1891, during firing trials at the Royal Dockyard at Horten, Norway, an explosion occurred of a 15^{cm}, 40-calibre, Krupp gun, M/88, constructed in 1891 for the *Viking*, causing the death of one man and severely wounding an officer.

The rupture occurred in the breech at the middle of the wedge, blowing it and a small portion of the breech 140 yards to the rear, and causing the chamber and part of the bore to expand 0.08 inch. No flaws in the metal were visible.

Previous to delivery the gun had been tested at Essen with charges of slow-burning powder, with the following results:

Charge.	Projectile.	Initial velocity.	Pressure.
Pounds.	*Pounds.*	*f. s.*	*Tons.*
58.3	112.2	2070	....
41.8	112.2	1893	16.86

The powder used at the Horten trials was P. P. C/82, which is employed in smaller charges in the old type of 10 to 15^{cm} guns. Fourteen rounds were fired with reduced charges of 26.4 pounds, developing 11.8 tons pressure. At the fifteenth round the charge was increased to 52.8 pounds, bursting the gun, with the above-mentioned results.

The pressure gauges in the breech-block showed the chamber pressure developed to have been between 40 and 46 tons per square inch. It seems evident that the powder employed was entirely too quick in its action to be used in such large charges in that type of gun.

RUSSIA.

The largest guns designed to be mounted afloat in the Russian navy are 12-inch B. L. R., weighing about 56 tons, built at the Oboukhoff factory.

SPAIN.

The government factory at Trubia is now turning out guns, built on the Ordoñez system, which are giving satisfactory results.

This type was adopted in January, 1892, for the use of the navy, and will, in future, supplant that of Krupp.

For coast-defense purposes, the Ordoñez guns are built of cast-iron, strengthened by wrought-iron hoops shrunk on, and lined with a steel tube, screwed into place, which contains the breech box and extends just forward of the trunnions.

Three of these guns were tried during June and July, 1891, one at Trubia and the others at Gijon, and gave the following results:

	No. 1.*	No. 2.†	No. 3.‡
Calibre	21^{cm} (8.27 inches)	24^{cm} (9.45 inches)	30.5^{cm} (12.01 inches).
Length of gun	35.6 calibres	35.6 calibres	35 calibres.
Weight of gun	16.3 tons	24.25 tons	47.44 tons.
Weight of projectile	286 pounds	429 pounds	836 pounds.
Weight of charge	99 lbs. (German P. P.)	154 pounds	264 pounds.
Initial velocity	1,706 f. s	1,706 f. s	1,706 f. s.
Chamber pressure		13.29 f. t.	13.86 f. t.
Initial energy	5,906 f. t.	8,825 f. t.	17,192 f. t.
Penetration, wrought iron (at 2,187 yards).	12.24 inches	14.57 inches	19.17 inches.
Weight of carriage	17.18 tons	18.85 tons	
Angle of elevation	+25° —10°	+23° —10°	
Range . 25° elevation	12,030 yards		
Range . 22° elevation		Over 12,000 yards	
Number of rounds fired	42	58	25.
Cost	$4,500	$5,400	$9,000.

* Using shrapnel weighing 209 pounds, an initial velocity of 2,021 f. s. was developed, with a chamber pressure of 11.39 tons per square inch.

† Five projectiles fired at a target 6 miles distant struck in a rectangle 131.2 yards by 32.8 yards.

‡ Using charges of 264 and 275 pounds a slight deformation of the tube resulted, occasioned by the excessive softness of the steel used. On account of the expense, this gun was not taken to the Gijon firing grounds to test its mount and range.

Although not as powerful as recent high-power guns adopted in other countries, these guns are of much less cost; and this fact, taken in consideration with the character of the coast they are to defend, they are accepted as fulfilling all requirements.

Ordoñez guns of 12^{cm} and 14^{cm} calibres, have also passed successful tests and been adopted.

UNITED STATES.

The largest guns yet completed for service afloat are 12-inch 45-ton B. L. rifles; total length 36.8 feet, firing a projectile weighing 850 pounds.

During powder-test firings with the first gun, an initial velocity of 1,951 f. s. was attained, with a chamber pressure of 15 tons per square inch; the second gun, with an improved sample of powder (Dupont brown prismatic), developed an initial velocity of 1,996 f. s., with a chamber pressure of 14.6 tons per square inch.

RAPID-FIRE GUNS.

The year's progress in rapid-fire guns is marked by the adoption of the Krupp type in Germany; the decision of the French to transform their new guns, of 16^{cm} and less calibres, so as to admit of an increased rate of fire; the adoption of the Canet system by both France and Russia; and of the Dashiell system by the U. S. Navy.

CANET 80 CALIBRE, 57^{mm} R. F. GUN.

The remarkable degree of velocity which can be imparted to a projectile by increasing the length of the bore of the gun was exemplified at Havre in May last, when a 57^{mm} (6-pounder) Canet R. F. gun, 80 calibres long, developed an initial velocity of 3,325 f. s., with a chamber pressure of 16.98 tons per square inch. This is the highest velocity known to date.

Following are the data of firings conducted during May and June, 1892, with this gun:

Weight of projectile.	Kind of powder.	Weight of charge.	Initial velocity.	Pressure per square inch.
Pounds.		*Pounds.*	*f. s.*	*Tons.*
5.94	BN_1.	1.76	2,126	6.44
5.94	BN_1.	2.42	2,595	11.14
5.94	BN_1.	2.64	2,801	12.38
5.94	BN_1.	3.08	3,110	17.04
5.94	BN_1.	3.19	3,218	20.07
5.96	BN_1.	2.92	2,818	12.70
6.60	BN_1.	2.92	2,739	13.10
6.60	BN_1.	3.08	2,821	13.40
5.94	BNG.	2.20	2,559	9.10
5.94	BNG.	2.64	2,972	12.81
5.94	BNG.	2.86	3,143	14.35
5.92	BNG.	2.97	3,189	14.53
5.94	BNG.	2.97	3,274	16.08
6.60	BNG.	2.86	3,123	15.88
5.94	BNG.	3.08	3,284	16.27
6.60	BNG.	3.08	3,297	19.58
5.94	BNG.	3.08	3,325	16.98
6.60	BNG.	3.08	3,215	17.03
6.60	BNG.	3.08	3,264	17.32

CHILE.

Canet.—The trials at Havre, February 26, 1892, of the battery of the *Presidente Pinto* are interesting from the fact that they included the first test for rapidity of fire of a Canet rapid-fire gun of medium calibre, mounted afloat.

After satisfactory reception trials of the main battery, a 12^{cm} (4.72-inch) rapid-fire gun, served by a crew of four men, fired a salvo of 10 rounds against time. Fixed ammunition was used, smokeless powder, and 46.2-pound projectiles. The time elapsed from the order "Load" to the last discharge was 54 seconds.

Previous firings on the proving grounds had given 5 shots in 24 seconds.

Hotchkiss.—On August 23, 1891, during the battle of Vina del Mar, the breech-block and part of the breech of a 14-pounder Hotchkiss R. F. gun of the *Almirante Lynch* blew out, killing the officer firing the gun. The fracture showed no flaws, and it is to be presumed, when the reputation of the Hotchkiss Ordnance Company is considered, that the accident was caused by excessive chamber pressure. The breech housing parted longitudinally, just forward of the guides, and the tube moved forward $\frac{1}{32}$ of an inch in the jacket.

One theory of the cause of the rupture is that, the supply of loaded ammunition being exhausted, the Chileans improvised some by filling used cases with a quicker powder, and employed Armstrong or Krupp shells, enlarged, perhaps, to fit the expanded case. As the capacity of the case is $7\frac{3}{4}$ pounds, whereas the charge is 6.6 pounds S. P. powder, and the expansion of the used cases is 0.02 inch at the mouth, the chances of one or both of these errors having taken place seem very plausible. The range of the projectile, only 8 yards, the forward movement of the tube, and the fact that no flaws showed in the rupture of the breech, all seem to indicate that the accident was caused by an enormous pressure developed in some such manner.

ENGLAND.

During the year ending December 31, 1891, there were added to the naval service eight 6-inch and two hundred and twenty-five 4.72-inch Armstrong R. F. guns, making in all 1,715 rapid-fire guns afloat and in reserve in the English navy at that date.

The year's development of rapid-fire guns of large calibre is marked by the first introduction into service afloat of the 6-inch Armstrong R. F. gun, the manufacture of which had been delayed pending the adoption of cordite. Ten of these guns have been mounted in casemates on board the *Royal Sovereign.*

During sea trials, January 13, 1892, of a new 6-inch R. F. Elswick mount, using cordite, an initial velocity of 2,660 f. s. was imparted to a 100-pound projectile, and a point blank range of 1,000 yards attained. Where the alterations in elevation and direction were slight, the vessel being underway, three series of ten aimed rounds each were fired in 1 m. 57.8 sec., 1 m. 59.8 sec., and 1 m. 58.3 sec.; with greater changes in train, 20 shots were fired in five minutes.

DRIGGS-SHROEDER R. F. GUN.

During the past year, the 3-pounder Driggs-Shroeder R. F. gun purchased by the English Government, has been subjected by them to a series of trials. The following is an extract from an article by Lieut. Driggs, U. S. Navy, the inventor of the system, published in the *Proceedings of the United States Naval Institute:*

> In the preliminary test for strength, etc., the pressures and velocities reached were as follows:

Velocity.	Pressure.
f. s.	*Tons.*
2,005	12.8
2,089	19.7
Not taken.	16.3
2,121	16.7
2,142	18.8
2,165	19.2

> The main object of this part of the trial being for strength of gun, the powder charge was set to produce high pressures without regard to velocities. With suitable powder, the gun will give 2,100 f. s. with a pressure under 15 tons. The breech closure worked smoothly throughout. Tests were then made to see the effect of defective ammunition. For this purpose eight split cases and three pierced primers were the results out of 20 rounds. We believe this is the most severe test a gun of this class has ever been put to, but it can be said also to the credit of the piece, that with the exception of one misfire (which occurred after one of the blow-backs through the primer, and this cap was exploded on second trial), that the gun worked perfectly throughout. We mention this test particularly, as rivals have claimed that with blow-backs or high pressures the breechblock will stick. Four Driggs-Shroeder guns have been subjected to official tests, all of which have been satisfactory, and in no instance has the breech mechanism stuck.

From the same source we obtain the following data of small calibre guns of this system:

	1-pounder.	3-pounder.	6-pounder.
Calibre, inches	1.457	1.85	2.244
Length of bore, inches	58.28	81.45	100.98
Length of bore, caliber	40	44	45
Length of rifling, inches	51.9	65.75	98.3
Length of gun, inches	61.08	87.26	107.98
Number of grooves	12	20	24
Depth of grooves, inches	0.015	0.0158	0.015
Width of lands, inches	0.0594	0.0787	0.0737
Weight of gun complete, pounds	100	497	800
Weight of breechblock, pounds	5	16	26
Weight of powder, ounces	4.6	27.53	31.5
Weight of projectile, pounds	1.1	3.3	6
Muzzle velocity of projectile, f. s	1,800	2,100	1,880
Number of fires per minute	40	33	30

Twist of rifling:

1-pounder, 1 turn in 30 calibers.
3-pounder, 1 turn in 100 to 1 in 25 calibers.
6-pounder, 1 turn in 150 to 1 in 27 calibers.

In the 3 and 6 pounder the twist of rifling is that of a semi-cubical parabola. Theoretically, this curve produces less strain on the rotating band than any other, and less than a uniform curve.

FRANCE.

During the past year great activity has been shown in France in the development and adoption of rapid-fire guns of large calibres. Heretofore their largest gun of this type has been of 65^{mm} calibre, their latest types of 10, 14, and 16 centimetre guns, M/ 81, 84, 87, and 91 being ordinary breech-loading high-powered guns. Recognizing the increased effectiveness of rapid-firing guns of the above-mentioned calibres, steps are being taken to convert these B. L. rifles to R. F. guns, and, in addition, the French navy has adopted the Canet R. F. guns, several of which are now mounted afloat.

The Naval Budget for 1892 appropriates $148,000 for converting B.L. rifles to R. F. guns, and $848,000 for the construction of R. F. guns; also, $730,000 for fixed ammunition for the former, and $440,000 for the latter, allowing a contingent of $200,000 to be used at the discretion of the Minister of Marine.

In 1887 France commenced preparations to arm her navy with high-power guns of the smaller calibres, so that now she possesses 650 B. L. rifles of 10, 14, and 16 centimetres calibres, capable of being converted into R. F. guns. Three hundred and thirty-seven of these, comprising 298 M/ 81 and 84, and 39 M/ 87, have been ordered to be converted as soon as possible, and put in service on board vessels of the 1st class; and of the remaining 313 M/ 91, 110 are proposed for the batteries of vessels now building, and the other 203 to replace those first converted. It is expected that the French will have 250 R. F. guns of large calibres afloat by the end of 1892.

CONVERTED R. F. GUNS.

The conversion of the B. L. rifles to R. F. guns consists in fitting an extractor and firing pin with trigger mechanism to the breech block, and reënforcing the chase with a hoop having a swell at the muzzle. Three motions are still required to open or close the breech. The sights being on the gun, M/81–87, recoil with it, constituting a great drawback for rapid-firing guns, as the gun captain must be placed well to the rear, and has his line of sight disarranged at each discharge. With the converted guns, M/91, it is intended to fit the sights to the gun cradle, and also, to so modify the breech mechanism that it will operate in two motions.

The principal alterations are required in the mount, and consist of placing the elevating and training gear on the same side of the gun, so that they can both be operated by the gun captain as he sights the piece; the addition of a spring for automatic return to battery after firing; and the fitting of a brass shield to protect the gun captain during the opening of the breech.

Fixed ammunition is used, which renders sponging after each round unnecessary.

Using BN. smokeless powder, the converted guns are expected to give the following results:

Gun.	Calibre.		Projectile.	Initial velocity.	Penetration (steel).
	Cm.	Inches.			
			Pounds.	*f. s.*	*Inches.*
M 81 T. R.*	10	3.94	30.8	1,837	6.2
Do	14	5.51	66.0	2,099	9.1
Do	16	6.3	99.0	2,132	10.24
M 87 T. R.*	14	5.51	66.0	2,624	12.2
Do	16	6.3	99.0	2,624	13.9

* Tir Rapide.

The first 10^{cm}, 28 calibre, 1.15-ton, M / 81 T. R. has attained the required initial velocity, but it is considered doubtful by many if the M/91 guns are of sufficient length to produce the required 2,624 f. s. velocity.

The following are the results of trials held at Gâvres, December 24, 1891, and at Sevran-Livry, January 14, 1892, with "M/81, T. R," converted guns:

Calibre.	Date of trial.	Charge.	Projectile.	Complete cartridge.	Initial velocity.	Pressure per square inch.	Unaimed shots.		Alternate targets of varying heights.		Alternate targets 19.7 feet apart; elevation fixed.	
							No. of rounds.	Interval.	No. of rounds.	Interval.	No. of rounds.	Interval.
Cm.		*Lbs.*	*Lbs.*	*Lbs.*	*f. s.*	*Tons.*		*Sec.*		*Sec.*		*Sec.*
14	Dec. 24, 91	.....	66	98	2109	......	10	69.7	10	76¼	....	....
10	Jan. 14, 92	4.95	30.8	.....	1837	13.9	....	....	....	....	10	95

On the same date, January 14, 1892, on which the 10^{cm} French gun was tried, the Armstrong 4.72 inch and 6-inch R. F. guns, which had been purchased by France for experimental purposes, were tried. The conditions under which they were fired were so different from those of the French gun, and the results so inferior to those which are known to have been obtained with these guns in England, that a comparison of the relative efficiency of these two types cannot well be made from the data obtained. The following results were recorded with the Armstrong guns:

Calibre.	Charge.	Projectile.	Initial velocity.	Pressure per square inch.	Number of rounds.	Time elapsed.	Range.	Target.
Inches.	*Pounds.*	*Pounds.*	*f. s.*	*Tons.*		*Seconds*	*Yards.*	
6	16.5	99	2,132	14.56	5	140	131	Two, 19.7 feet apart, each lowered 9.8 inches for successive shots.
4.72	5.2	46.2	1,935	14.56	5	75	131	Fixed target.

The English papers attribute the low velocities obtained to the fact that BN powder is less powerful, weight for weight, than cordite, for which the Armstrong R. F. guns are constructed.

CANET R. F. GUNS. FRANCE.

During the discussion of the naval budget for 1892, Gen. du Pan informed the Chamber of Deputies that it was not until the end of 1890 that the Canet R. F. guns fulfilled the necessary conditions for adoption.

On July 8, 1891, trials of 12 and 15^{cm}, 45-calibre, Canet R. F. guns were conducted by a French commission at Hoc Polygone. The Commission stipulated that the pressures should not exceed 15.19 tons per square inch, as the cartridge cases swell and jam when pressures approach 19 tons, and fixed the weights of the charges at 12.1 and 21.45 pounds for the 12 and 15^{cm} guns, respectively.

Following are the data of this trial:

Calibre.	Weight of gun.	Weight of mount and shield.	Charge.	Projectile.	Initial velocity.	Pressure per square inch.
Cm.	*Tons.*	*Tons.*	*Pounds.*	*Pounds.*	*f. s.*	*Tons.*
12	2.47	7.2	12.1	46.2	Varying from 2460 to 2493	15.19
15	5.63	11.78	21.45	88		15.19

Rapidity of fire.

Calibre of gun.	Unaimed.		Fixed target.		Direction fixed. Elevation varying.		Alternate targets. Elevation fixed.		Alternate targets. Elevation varying.	
	No. of rounds.	Time elapsed.	No. of rounds.	Time elapsed.	No. of rounds.	Time elapsed.	No. of rounds.	Time elapsed.	No. of rounds.	Time elapsed.
Cm.		*Sec.*		*Sec.*		*Sec.*		*Sec.*		*Sec.*
12	9	54	11	108	5	37	5	77	5	73
15	10	57	10	92	5	60	5	52	5	120

The guns were served by professional men, but who were not familiar with Canet guns. No accidents; and the action of the breech mechanism and accuracy of fire were satisfactory. The Commission pronounced the guns as being first-class and recommended their adoption.

In December, 1891, ten 10^{cm} Canet R. F. guns were ordered from the works of Forges et Chantiers de la Mediterranée, and since then other orders have followed. These guns are required to give an initial velocity of 2,624 f. s.

La Marine Française states that during firing trials, December 16, 1892, a 15^{cm} Canet R. F. gun gave an initial velocity of 2,854 f. s. with a chamber pressure of 19 tons per square inch.

MAXIM-NORDENFELT, SEMI-AUTOMATIC.

During experimental firing of a semi-automatic 47^{mm} Maxim-Nordenfelt gun, conducted by the naval authorities, a rate of 15 shots a minute was attained when aiming at the center of the target, and 28 shots per minute when pointing simply at the target, which was 9.84 feet high and 6.56 feet wide. The trial was conducted at Sevran-Livry, where the range is limited to 131 yards.

GERMANY.

The following types of Krupp R. F. guns were definitely adopted in April, 1892, for use in the German Navy:

Calibre.		Length.	Projectile.	Charge.	Initial velocity.	Remarks.
Cm.	*Inches.*	*Calibres.*	*Pounds.*	*Pounds.*	*F. S.*	
15	5.91	35	76.1 100	15.4	2329 2034	
10.5	4.13	35	26.5 35	5.2	2329 2034	
8.8	3.46	30	19.8	....	2130	
5	1.97	40	3.9	....	2231	
6	2.36	21	....	....	....	Boat gun.

KRUPP RAPID-FIRE GUNS.

During the past year, Krupp rapid-fire guns, of which some details have been given on pages 328 and 332, No. IX, and page 142, No. X, have been adopted in the navies of Austria, Germany, and Holland, of calibres ranging from 5^{cm} to 15^{cm}. The following is a description of this system, employed with the larger types of these guns, in which references are made to Plate II.

The breech block is cylindro-prismatic, wedge-shaped, and opens to the right side of the gun, differing from the ordinary type, which opens to the left.

Breech mechanism: The breech-block, A, which is through-pierced for loading, is recessed to contain the firing mechanism, E, with its tumbler H; the locking screw, C, operated by the handle, D; and the extractor K. The covering plate, B, containing the trigger, I, and mechanism appertaining to it, is secured by screws to the right face of the breech-block. When the breech is closed (Fig. 4), its wedge shape causes it to bear at front and rear against the base of the cartridge and the rear face of the mortise, respectively. The locking screw, C, securing it in position, is provided with three half-slotted screw threads, *a*, of square cross section, which engage in corresponding grooves in a recess of the mortise of the piece, and the fourth full thread, *b*, which bears against the right side of the breech and contains a triangular notch. The inner end of its axis bears in a socket in the block, and its outer one, passing through the covering plate, carries the manipulating handle, D, keyed to it by the key, *d*, and pin, *f*. When the handle is turned 180° to the left, its movement is arrested by stop lugs, and the slotted threads, *a*, are completely disengaged, permitting the block to be withdrawn. A turn to the right 180° locks the threads, as in Fig. 4. The ribs, *w*, in the mortise fit in guide grooves in the block, the lateral movement of which is limited by the full thread, *b*, and the extractor striking lug *h*. A sheet of brass, *z*, is screwed to the left lower front face of the block, to clean off whatever residue may lodge in the mortise after firing.

Firing mechanism.—The hollow firing-pin, E, containing the spiral mainspring, is inserted in its recess in the block, and secured in place by a cap which screws, against the pressure of the spring, into the block. It is slotted in its right side to contain the head of the cocking tumbler, H. The other end of this tumbler, which is pivoted at *i*, is cut with a square notch, *k*, in which the dog, *m*, of the trigger, I, fits, and an inclined lug, *l*, which, fitting in the triangular notch of the full thread, *b*, cocks the piece when the locking screw is turned to the left. The trigger plate, I, held in the locking position by the double armed trigger spring, *n*, bearing on it and the covering plate, is fitted with a horizontal lug, *q*, which protrudes through the covering plate, and is cut with an elliptical hole, the axis of which is inclined to the axis of the bore. This hole is traversed by a pin, *r*, movable about a horizontal axis, and ending in a ring, *o*, to which is attached the lock string.

Action of firing mechanism.—When the piece is fired, the lug, *l*, falls into the triangular notch in *b;* the handle, D, turning to the left, forces the inner end of the tumbler, H, back, drawing the firing pin back until the lug, *m*, falls into the notch, *k*, of the trigger when it is at full cock. To insure the trigger not being released during the operation of loading, the rim, *p*, of the locking screw, which is partially cut away, then bears against the trigger until the breech is fully closed and locked. To fire the piece, a pull on the lock string causes the trigger lever, *r*, which bears on the covering plate and inside edge of *q* to move the latter, and hence the trigger plate, I, to the right, against the action of the spring, *n*, until the lug, *m*, is released from the tumbler, when the firing pin is free to move forward under the strain of its spiral spring.

Extractor.—In the right forward face of the mortise of the gun is cut a vertical semi-cylindrical groove in which sets the vertical pivot of the extractor, K; this pivot is fitted at its upper and lower ends with hurter lugs, *s*, projecting to the rear, and at its middle with an arm

KRUPP R.F. GUN

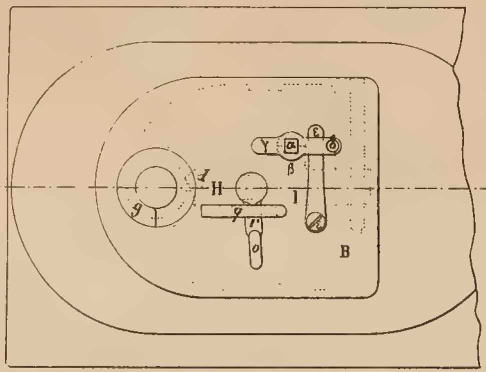


Fig.1. Right side of breech.

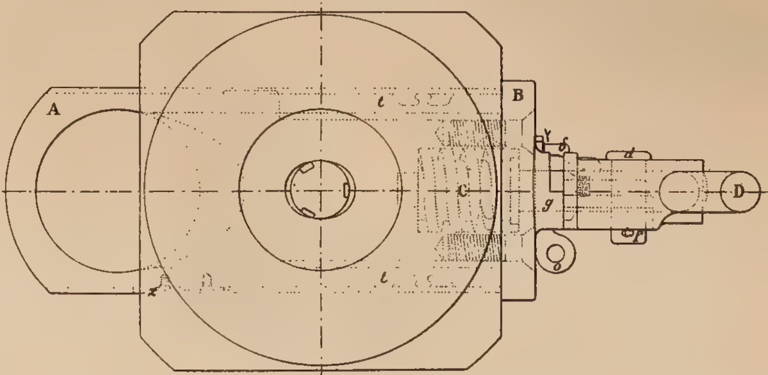


Fig 3. Rear View.

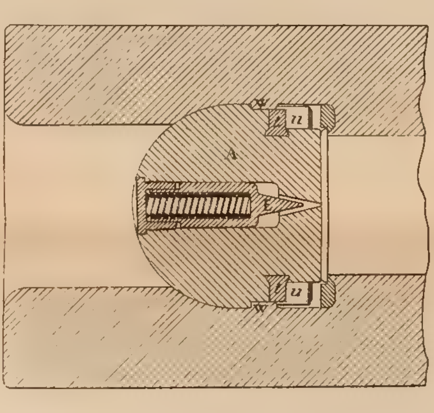


Fig 2 Longitudinal Section.

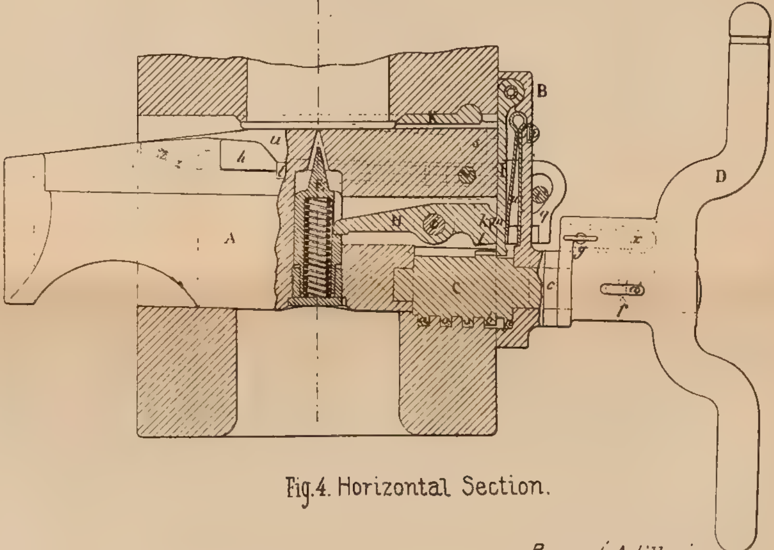


Fig.4. Horizontal Section.

Revue d' Artillerie

PLATE II

provided with a U-shaped prong which fits in a recess in the piece around the rim of the cartridge. Two lugs, for use in removing or replacing the extractor, project into the covering plate when the breech is closed. The breech-block is cut with grooves, *u*, terminating in the striking lug, *h*. When, after firing, the breech-block is drawn to the right, the lugs, *h*, striking the hurters, *s*, turn them slightly to the right until the charging hole is in line with the bore, when the action is sufficiently quick during the final movement to extract and eject the empty cartridge case to the rear.

To dismount the block.—Open the breech completely and then withdraw the vertical pin, *v*, which secures the sliding rods, *t*, in place; back out the rods, *r*, toward the covering plate until the strikers, *h*, are clear of the hurters, *s;* push forward on the prongs of the extractor, which will bring the pivot out of its seat in the mortise into the left end of the groove, *u;* then upon further withdrawal of the breechblock the extractor will come with it.

Automatic firing mechanism.—In a recess in an enlargement on the front side of the body of the manipulating handle, D, is the sliding rod, *x*, the end of which nearest the covering plate is wedge-shaped and acts on the trigger. To throw it into action the handle, D, is turned to the left, the rod, *x*, slid out, and secured in position by the clamp screw, *y*. When the handle is then turned to the right the wedge enters between the covering plate and the trigger stud, *q*, forcing it gradually out until, when the piece is locked, the movement is sufficient to release the stud, *m*, and discharge the gun.

Safety catch.—Through the covering plate projects the square-headed cylindrical bolt, *α*, jogged near the outer end to receive and hold the lug, *β*, which is on the upper edge of the trigger, I; on its head is shipped the crank, *γ*, with the handle, *δ*. This crank can be turned through 180°, and is limited in its movements by the spring, *ε*. When the crank handle is forward, the lug, *β*, is in the jog of the bolt, *X*, and the trigger is locked. When the handle is to the rear, the catch is released.

An interesting trial of the smaller calibre guns, 5^{cm}, 7.5^{cm}, took place October 7, 1891, on the Dutch gunboat *Het Loo*, for determining the rapidity of aimed fire; the guns being operated by their regular crews. The following were the best results obtained:

Calibre of gun.	Targets.			Range.	No. of shots per minute, firing at alternate targets.	No. of hits.	Greatest vertical error.	Greatest lateral error.
	No.	Distance apart.	Size.					
		Feet.	*Feet.*	*Yards.*			*Feet.*	*Feet.*
5 cm	2	65. 6	19. 6 by 19. 6	656	12	12	5. 9	5. 9
7.5 cm ..	2	65. 6	19. 6 by 19. 6	656	11	11	9. 5	6. 6

The following results have been attained with a Krupp 16^{cm}, L / 35 calibres, R. F. gun:

Weight of gun, including breech mechanism	tons	4.66
Weight of c. p. carriage	do	4.81
Weight of shield (1.18 inches thick)	do	1.68
Weight of projectile	lbs	94.6
Initial velocity	f. s.	2460
Weight of projectile	lbs	123
Initial velocity	f. s.	2132

For rapidity of fire, 10 shots fired in seventy-two seconds, 9 striking the target.

At a range of 2,734 yards, using projectiles weighing 123 pounds, the mean variations of 10 shots were 9.5 feet in height, and 6.4 feet laterally. When fired for rapidity of fire, the variations were 16 feet and 13.5 feet respectively.

RUSSIA.

Canet.—Although this type was accepted for trial purposes and reported to have been adopted for naval use last year, no large order has as yet been placed for its manufacture, but one 6-inch 50-calibre gun having been ordered.

Nordenfelt.—The Maxim-Nordenfelt Company, in England, has received an order for 100 6-pounder R. F. guns for coast fortifications.

During experimental firing at Ochta, October, 1891, of a 6-pounder Nordenfelt R. F. gun, a premature explosion occurred before the breech was fully closed, wounding one officer and three men. This accident was attributed by the Commission to be due to a defective cartridge and not to faulty design of the mechanism of the gun. A similar accident, which occurred on board the *San Martino*, at Spezia, in January, 1892, was stated in the public prints to have been due to the improper functioning of the safety-firing mechanism.

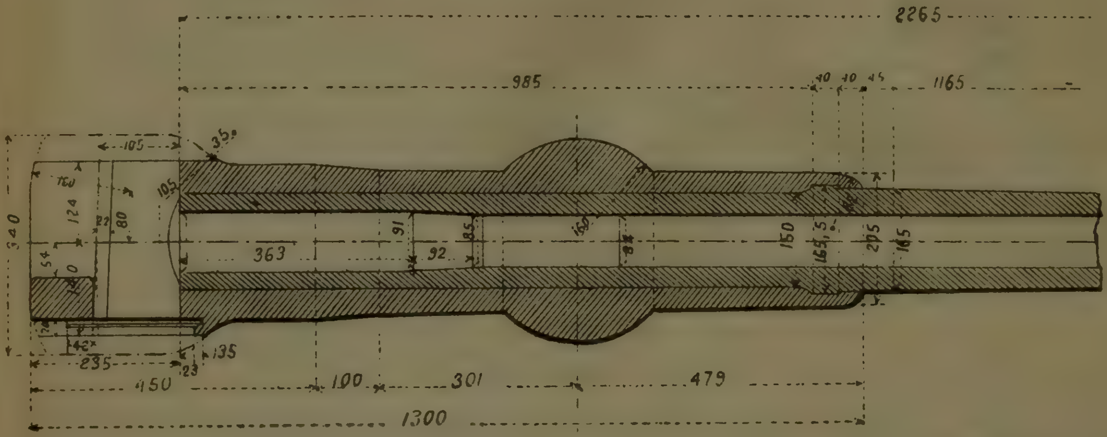
SPAIN.

The rapid-fire guns of large calibres, lately adopted for use in the Spanish navy, are Hontoria B. L. guns, converted into R. F. guns by a system designed by Lieut. Col. Rodriguez. Their weights and calibres are as follows:

	10^{cm} (3.94 inches).	12^{cm} (4.72 inches).	14^{cm} (5.51 inches).
Weight of gun ... lbs	3,960	5,830	9,350
Weight of projectile ... do	29.7	57.2	88
Initial velocity ... f. s.	2,132	2,132	2,132
Penetration at muzzle (wrought iron) ... inches	10.63	13.78	15.75

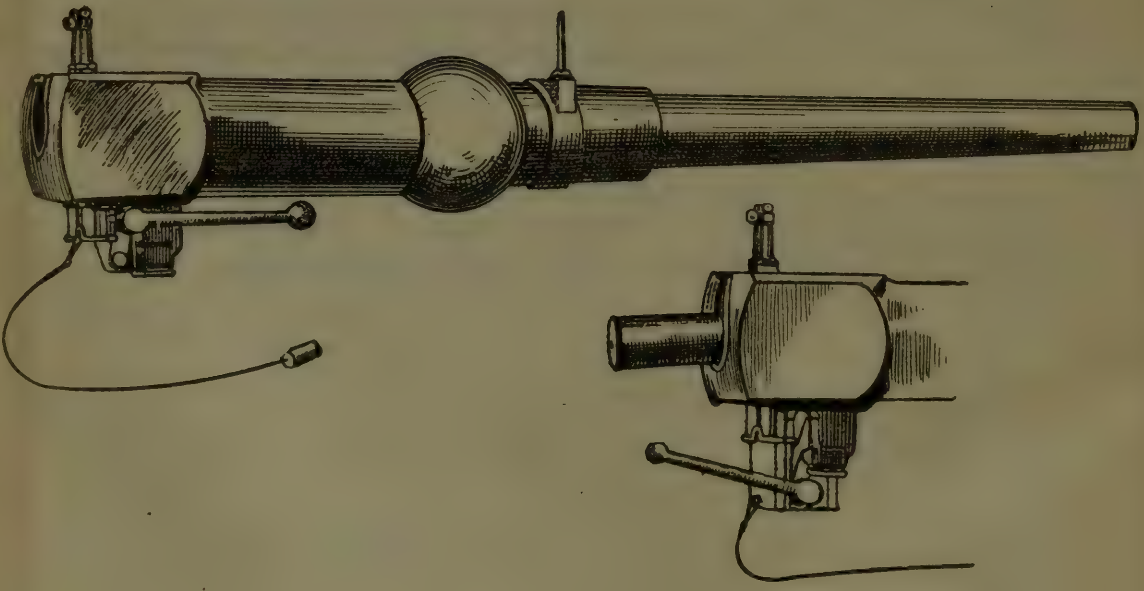
The first 14^{cm} rapid-fire gun, converted from a 12^{cm} breech-loading Hontoria gun at Le Creusot, was tried, November last, with charges of 44 pounds black powder and 88-pound projectiles. The initial veloci-

The ADAMSON GUN



Engineering

With
BOFORS R. F. Breech Mechanism.



Graphic

ties varied from 2,050 to 2,099 f. s., the chamber pressures not exceeding 15.83 tons per square inch. Better results are said to have been obtained using smokeless powder.

A rate of nine shots per minute has been attained with a 12^{cm}, L/35 calibres, gun; eight shots per minute with a 12^{cm}, L/40 calibres, and thirteen per minute with the latter, using automatic attachment to breech mechanism.

SWEDEN.

Adamson.—The distinctive feature of the Adamson R. F. gun, tested in Sweden during the past year by artillery officers, consists in the manner in which the gun is seated in its mount.

In lieu of trunnions the jacket is constructed with a spherical enlargement about the center of gravity of the gun (see Plate III), which is held in a socket of the mount; this ball and socket joint permits of quick train and elevation in all directions.

The gun tested was a 3.36-inch, 24 calibre, gun fitted with the Bofors rapid-firing breech mechanism.

Following are the details:

Calibre	inches	3.36
Length of gun	do	98.43
Weight of gun	pounds	1,200.
Number of grooves		24
Width of grooves	inches	.295
Depth of grooves	do	.039
Width of lands	do	.138
Volume of chamber	cubic inches	161.72
Twist at muzzle, one turn in calibres		33
Weight of projectile	pounds	14.75
Weight of charge (black powder)	do	5.51
Initial velocity (black powder)	f. s.	1,920.
Weight of charge (Nobel smokeless powder)	pounds	2.5
Initial velocity (Nobel smokeless powder)	f. s.	2,169.
Pressures	tons per square inch	19.8–21
Range (25° elevation)	yards	8,750

Eighty-five rounds were fired, during which the advantages claimed for quick pointing of the piece were fully demonstrated. The greatest rapidity of fire attained was five rounds in twenty seconds, which illustrates the effectiveness of the Bofors rapid-firing system.

Thronsen.—The Thronsen R. F. gun (page 134, No. X) has been adopted by the Swedish artillery and also by the Norwegian Government.

UNITED STATES.

DASHIELL MECHANISM FOR QUICK-FIRING GUNS OF LARGE CALIBRE.

The fermeture is on the slotted screw system. The plug is supported, when withdrawn, on a hinged tray and collar of suitable shape. All operating mechanism is carried on the tray casting, except the trigger, which is on the gun.

A curved translating arm of bell-crank lever form is pivoted to the tray at one end. A vertical toe at the other end engages an undercut score in the breech plug. When this lever swings on its pivot, the plug, if unlocked, will be withdrawn from or entered into the breech.

In the elbow of this arm is pivoted a horizontal cogged segment, formed in one piece, with a long lever ending in a vertical handle, or grip. A curved slot in the tray allows its pivot pin to move with the pivot of the translating arm as a center during longitudinal motion of the plug on the tray. This cogged segment engages a series of horizontal cogs on a rack bar which slides in a groove in the front of the tray. The left-hand end of this bar is provided with vertical cogs engaging another series on the lower part of the breech plug. A stop-pin on the face of the breech limits the travel of the rack. The length of the rack is such that its extreme right-hand cog is immediately below the pivot pin of the translating arm when the plug is unlocked. The usual double-acting latch is fitted to the tray.

The plug being locked, a pull on the hand lever rotates the cogged segment, thus unlocking the breech plug by means of the rack bar described. As soon as the plug is unlocked the stop pin will have checked the motion of this rack and the center of motion will be transferred to its right-hand cog, which is now immediately below the pivot pin of the translating arm. The arm and lever consequently swing together, and the plug is withdrawn on the tray and swung to one side clear for loading. As the plug comes out a groove cut in its threaded lower segment passes over the central tooth of the rack.

In returning the plug to the breech two forces will be at work in the mechanism—one to rotate the plug, the other to push it home. The first is checked by the groove in the plug engaging the tooth of the rack mentioned and pulling the plug against the tray rib. Only the motion of translation can thus take place. As soon as it is entirely off the tray ribs the plug can revolve, but being then home in the breech its translating motion ceases and revolution locks it in place.

The extractor is a strong bar kept down by a mild spring. It passes through a hole in the plug so as not to interfere with the threaded parts. By utilizing a certain amount of fore and aft "lost" motion the extractor is kept from slipping off the cartridge head at the same time that the plug, when pulled quickly to the rear through this "lost" distance, acts very powerfully as a hammer to extract the empty case.

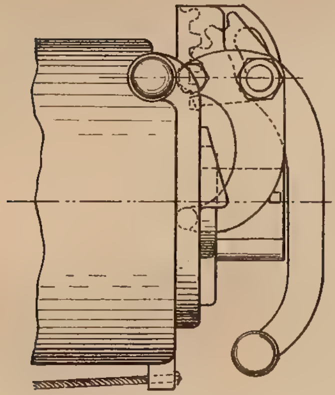
The extractor is shown in its forward or pulling position. When pushing a cartridge home the extractor hook cannot rise and catch until it has been pushed back, by the forward motion of the plug, to its rear position. It can then snap over the rim of the case and is ready for the blow from the breech plug in extraction.

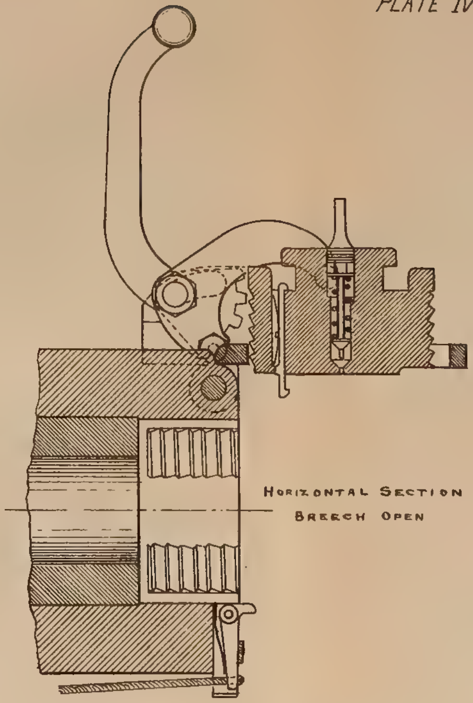
The firing mechanism consists of a straight firing pin, with cone-shaped shoulder and finger hook. A spiral spring actuates it, being held to its work by a loose, spool-shaped sleeve. A cocking lever is

PLATE IV

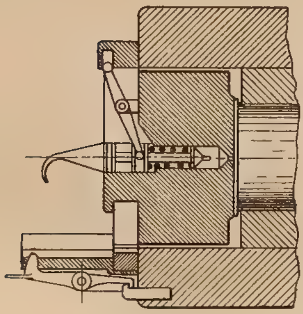
DASHIELL MECHANISM
FOR
QUICK FIRING GUNS
OF
LARGE CALIBER

TOP VIEW : BREECH CLOSED

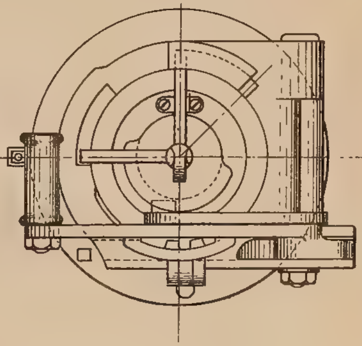




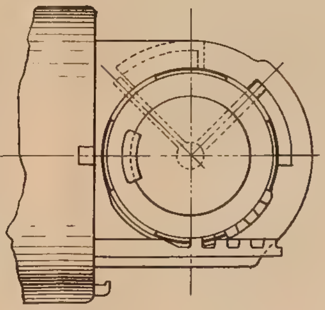
HORIZONTAL SECTION
BREECH OPEN



VERTICAL SECTION
BREECH CLOSED



REAR VIEW
BREECH CLOSED



FRONT VIEW OF PLUG
BREECH OPEN

pivoted to the plug, its upper end running along a cam groove in the tray collar, while its lower end is forked to engage over the spool-shaped sleeve on the firing pin. When unlocking, this lever moves the sleeve to the rear, cocking the pin on the toe of a horizontal sear bar. When locking, the sleeve is given motion in the opposite direction, which compresses the spring, leaving the firing pin cocked. When fully locked, the outer hook of the sear engages the trigger.

It will be seen that the gun cannot be fired unless the mainspring is compressed and the sear and trigger engaged, neither of which takes place until the last instant of locking.

The lanyard leads forward, around a pulley near the trunnions, if desired, so that the gun captain and lanyard will be out of the way of the gun servants about the breech, and the pull for firing will be independent of the elevation of the piece.

The advantages claimed for this mechanism are efficiency, with cheapness of manufacture. The quick-acting part is applicable to any gun with slotted screw fermeture in which the breech plug is worked by manual power.

Five rounds have been fired in seventeen seconds from the naval 4-inch gun fitted with this mechanism, the gun's crew having been drilled for two minutes before the salvo was fired.

MACHINE GUNS.

MAXIM AUTOMATIC MACHINE GUN.

This type of machine gun (page 364, No. VII) is meeting with success abroad as shown by the number of countries adopting it, in spite of adverse criticisms which appear from time to time.

It is reported that during the Wissman African Expedition the gun proved unsuitable to hard campaign service, owing to its delicate mechanism, which was liable to be put out of action by a little sand or ordinary blow, and required the services of a skilled gunner. The swelling of the ammunition bands, from dampness, and the necessity for water supply are also drawbacks for shore service.

The gun has, nevertheless, passed very successful experimental trials and is now in service in seven countries abroad.

Austria.—The 130 guns of this type ordered by Austria were intended to be of 11^{mm} calibre, and the two barrels supplied to each gun to fire 16,000 rounds apiece; when the calibre was changed to 8^{mm} 11,000 rounds were found to be the life of a barrel, and each gun is now to be supplied with three. The order has been fulfilled, and the guns and barrels accepted, five of the latter, chosen indiscriminately, having successfully withstood the regulation number of rounds fired in series of from 200 to 1,200.

Only one gun of this type is in naval use.

Denmark.—The Naval Budget for 1892–'93 provides for ten Maxim machine guns, calibre 8^{mm}, for naval purposes.

England.—The few guns of this type which have seen service afloat have given satisfactory results, working well at any elevation.

Their manufacture is now in progress at the small-arms factory at Enfield, as well as at the company's works, a recent order from the Admiralty for 170 guns, calibre .303 inch, being about equally distributed between the two places.

The practice in England is to replace the barrels after the gun has fired 11,000 rounds; in October, 1891, a barrel tested to destruction fired 49,500 rounds before bursting.

France.—After testing a 37^{mm} gun on board the *Curonne*, a board of officers recommended its adoption into service.

Germany.—With some modifications, the system has been adopted in Germany, and a large plant has been erected in that country for their manufacture; 180 guns have been ordered for naval purposes, to be built in Germany.

Italy.—The navy possesses about 50 guns of small calibre. While the mechanism is recognized as being delicate, and a superior grade of ammunition is necessary, the guns generally give satisfaction. The principal trouble is found to exist with the springs.

Switzerland.—The government has lately ordered 24 guns of small calibre with a supply of ammunition.

Mr. Maxim, in an article in *Engineering*, gives the following as the rapidity of fire at various trials, the rates being dependent on the ammunition employed.

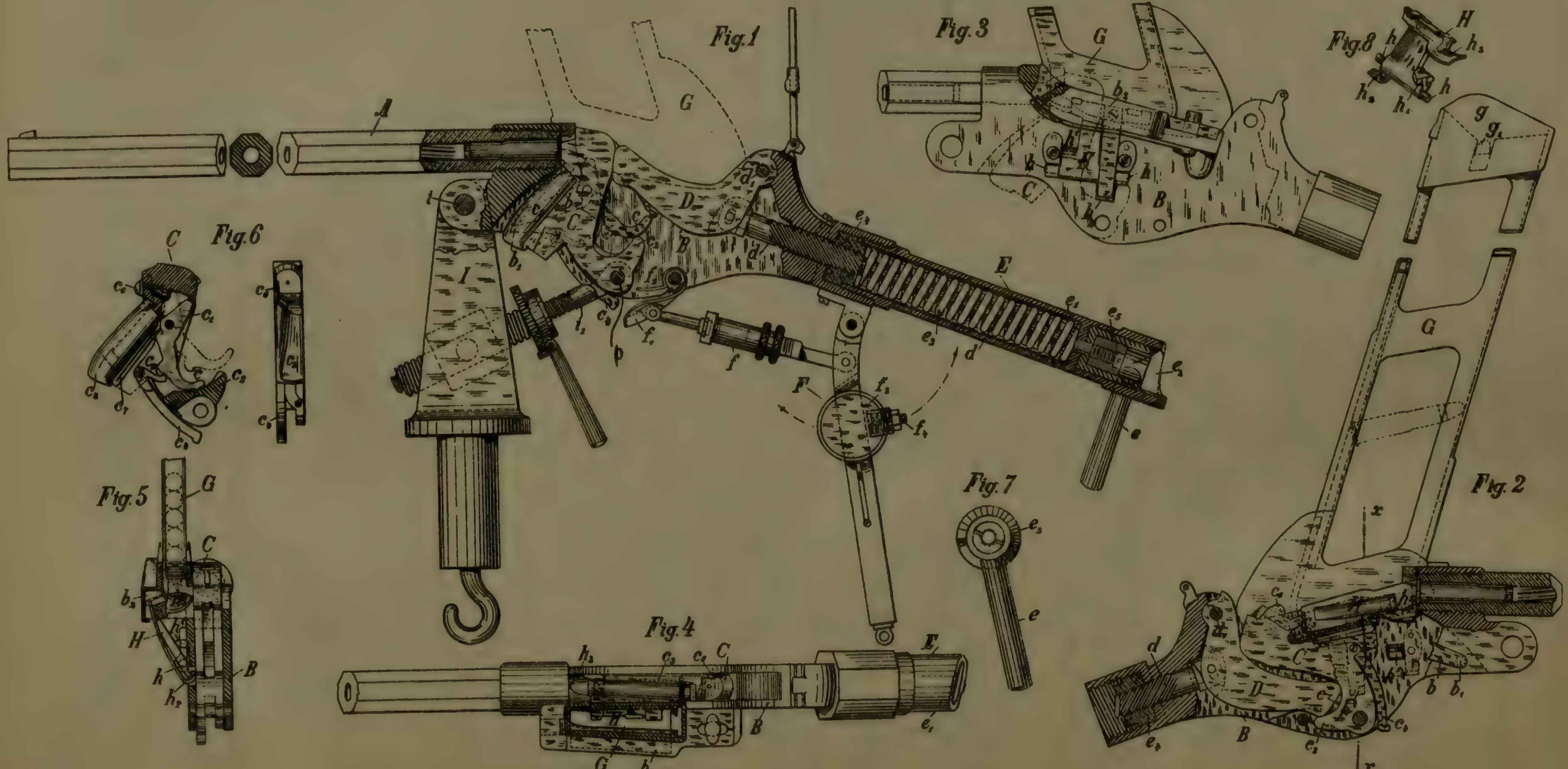
Place of trial.	Ammunition type.	Rate of shots per minute.
Austria	Old Männlicher	620
Do	New Austrian	770
England	Royal Woolwich	666
Do	U. S. Service	742
France	New Gras (French)	*700
Germany	Various	600 to 700
Italy	Old Vetterli	300
Do	German Mauser	620
Russia	Old Berdan	444
Switzerland	German Mauser	612
United States	Union Metallic Cartridge Co	775

* Nearly.

Mr. Maxim also states that commissions of both French and German officers have decided that a rate of 250 shots per minute is sufficient for producing the best results.

For use with blank cartridges, Maxim has constructed a gun which is operated by the blast of the gases at the muzzle. Its rapidity of

SKODA MACHINE GUN



action is so great that the English reduced the blank charge from 60 grains of black powder to 42 grains; and, in France, a belt of 20 Lebel cartridges was fired at the rate of from 1,100 to 1,200 per minute.

AUSTRIA.

SKODA MACHINE GUN (Calibre 8^{mm}).

A new automatic machine gun, the invention of an Austrian archduke and Capt. Dormus, of the Austrian artillery, has passed very successful tests before a committee, firing series of from 30 to 1,200 rounds without serious mishap, and it is to be introduced into the Austrian army. Its manufacture has been commenced at Skoda's works at Pilsen, from which works it takes its name.

It is a single-barrel gun, calibre 8^{mm}, the working of which may be understood from the following description and Plate V.

Breech mechanism.—The breech-block C, pivoted at *p*, is recessed to contain the firing mechanism, and when closed is held in position by the block support D. This support D, pivoted at d^1, is continually under the pressure of the accumulator spring E, through the spindle *d*, and exercises a forward pressure on the block C. When the piece is fired, the shock of recoil, exerted against the face of the block C at the instant the bullet leaves the bore, forces it to the rear, it in turn driving back the support D against the spring E, causing its forward end to revolve downward. A quick screw-thread is cut on the forward end of the spindle *d*, which works through the nut e^4. This nut is cylindrical and a neat fit in the casing; its shoulder serves to relieve the spring of part of the strength of the recoil, and the friction of revolving diminishes the speed with which the breech is opened and closed. As soon as the momentum of recoil is expended, during which time the empty cartridge case is ejected and a new cartridge is supplied from the magazine on to the nose c^3, both automatically, the spring E forces the support D forward, closing the block C and pushing the cartridge into the barrel. The rear end of the spindle *d* screws into the round nut e^5, which is a neat fit in the casing, and also serves to hinder the lateral movement of *d*. To load the first cartridge by hand, the handle *e* is turned to the right, and, taking in a screw-thread in the casing e^2, draws the spindle *d* to the rear; the breech is closed by a reverse movement of *e*, after which, on firing, e^5 slides in the casing. In order to ease the breech-block from closing too sharply, the spring *b* is set in the breech-casing, having a lug, b^1, which bears on the nose of the block and checks it by friction.

Firing mechanism.—The firing pin c^8 is struck by the arm c^1 of the hammer *c*. This hammer is made with a curved toe *c*, which is pressed forward by the breech-block support D during its downward motion and serves to cock the piece. It also has the notch c^5 in which the hook of the trigger-arm c^4 takes. The mainspring is shown at c^7 bearing on the front of the hammer.

When the arm c^4 is pressed down, its hook is released from the notch c^5, and the head of the hammer driven forward by the spring c^7, firing the piece. This is accomplished by means of the automatic firing apparatus. To a swinging arm F is fitted the movable pendulum-weight f^3. This pendulum is connected with the trigger f^1 by the adjustable arm f. To increase the impulse of the pendulum movement, the spring f^2 is provided to act at its forward limit of motion, and f^4 when at its rear limit. The shifting of the weight f^3 up or down will increase or decrease the rapidity of swing.

The action of the pendulum is as follows: The pendulum swinging forward, the trigger f^1 strikes c^4 and fires the piece. The breech-block revolves instantly and the toe c^2, striking the trigger f^1, drives the pendulum back until f^4 strikes the casing e^1, when it returns forward for the next discharge, and so on.

Extractor.—The extractor is a spring clutch let into the side of the breech-block, and is said to be rather clumsy, but works well enough.

Ammunition supply.—The magazine G, either vertical for field guns, or curved to suit the space in casemates or cupolas, has two grooves guiding the cartridges, which feed by their own weight; it is shipped on the box h^2, of the breech casing, over the carrier H. This carrier H is pivoted on the outside of the casing at h h, and has two lugs h^1 and h^2, on its side, and on its top the curved cartridge shelf h^3, all of which project into the casing. The lug h^3 is provided with a spring, the tension of which acts to throw h^3 to the right. When the breech is closed, the lower cartridge in the magazine rests on the shelf h^3; upon the discharge of the gun, the block C, revolving to the rear, clears the lug h^1 and presses on h^2, which causes the carrier h^3 to revolve into the casing, placing the cartridge on the nose c^3, where it is grasped in position for loading, as shown in Fig. 3. The forward movement of the block C causes it to force the lug h^1 out, at the same time clearing lug h^2, and the carrier resumes the position shown in Fig. 5, the shelf h^3 having remained under the cartridge a sufficient time during this return movement to insure its entering the breech fairly when pushed by the block C.

The magazines contain from 20 to 40 cartridges, and during automatic firing may be replenished by ammunition carriers from above.

For single firing, the pendulum is grasped on its backward swing and let go for each discharge.

It is stated that a rate of more than 400 rounds a minute may be attained with this weapon.

GUN MOUNTS.

ENGLAND.

TRIAL OF THE ROYAL SOVEREIGN'S 67-TON GUNS.

The hydraulic engines and machinery are similar in type to those of the *Trafalgar*, for the trials of which see page 80, No. IX, but are designed for more rapid firing, the hydraulic pumps having 36 per cent more horse power, and the turning engines being capable of working 50 per cent faster.

To reduce weight, all cylinders and rams are made of steel. The transportation of the projectiles from their racks in the shell room to the bore of the guns is effected entirely by hydraulic power.

Each gun is expected to be able to maintain a rate of fire of one round every two minutes. The best record with the *Trafalgar's* gun is four rounds in nine minutes and seven seconds from fire to fire.

The *London Times* gives the following account of the trials which took place April 22, 1892:

The 67-ton gun has a total length of 36 feet 1 inch, a length of bore of 405 inches (equal to 30 calibers), and the rifling extends for 333.4 inches. The diameter of the powder chamber is 18 inches, of the jacket 57 inches, and of the chase at the muzzle 23.4 inches. It fires a full charge of 630 pounds of S. B. C powder (the cartridge being made up in quarters) and a reduced charge of 472½ pounds, and discharges a projectile of the approximate weight of 1,250 pounds.

AFTER BARBETTE.

Gun.	Round.	Charge.	Elevation.	Bearing.	Recoils.	
					Ft.	*in.*
Left gun	1	Reduced	Horizontal	Port beam	2	7
	2	Full	5° elevation	10° before port beam	3	7
	3	Full	Horizontal	10° abaft port beam	3	7
Right gun	1	Reduced	Horizontal	Port beam	2	7
	2	Full	5° elevation	10° before port beam	3	7
	3	Full	Horizontal	10° abaft port beam	3	7

FORWARD BARBETTE.

Left gun	1	Reduced	Horizontal	Starboard beam	2	3
	2	Full	5° elevation	10° before starboard beam	3	6
	3	Full	Horizontal	10° abaft starboard beam	3	4
Right gun	1	Reduced	Horizontal	Starboard beam	2	3
	2	Full	5° elevation	10° before starboard beam	3	6
	3	Full	Horizontal	10° abaft starboard beam	3	4

It will be seen that the firing was confined to three rounds from each gun, the third from the right and left guns in the forward barbette being discharged simultaneously. The breech of the right gun in the same barbette was also worked part of the time by hand gear. For prudential reasons, as the ship is practically ready for sea, it was not considered advisable to point the guns either direct ahead or direct astern, but to fire only on the beam. Again everything passed off satisfactorily, and with the exception of a few lamps and a little glass nothing was carried away and no damage inflicted. Even the salvo was hardly to be distinguished by volume of sound from the single rounds, though of course the shocks were perceptibly greater.

The mounts admit of 13° elevation and 5° depression on the beam, but there is an automatic arrangement which lays the guns level when pointing directly ahead or astern, no depression being then allowable. The arc of train of each gun is 240°, and 31 seconds are required to sweep it.

CASUALTIES.

During target practice, with full charges, with the 67-ton guns of the *Trafalgar*, last July, the locking bolt of the left gun of the after turret broke, and in attempting to get the gun into firing position the bed of the right gun shifted, putting the turret entirely out of action, it requiring three days and nights to repair the damage.

While at target practice during the manœuvres of last year, a defect in a pipe connected with one of the recoil presses put one of the *Sans-pareil's* 110-ton guns out of action for two hours.

VAVASSEUR'S HOUSING APPARATUS.

For the purpose of housing the 6-inch R. F. guns mounted, in casemates on the main decks of the *Royal Sovereign* and *Grafton* classes, on Vavasseur c. p. rapid-fire gun-mounts (page 149, No. X), Vavasseur has designed the following apparatus, two of which are to be supplied to each vessel:

Over each gun (see Pl. VI) is fitted a pair of overhead rails, *e*, with a rack, *g*, between them. Traveling on these rails, on the rollers, $f^1 f^1$, is a truck which carries the axle, f^2, on which are fitted a cogged wheel, gearing into the rack *g*, and a worm-wheel actuated by the horizontal worm *f*. The latter is turned by endless chains on wheels at its ends. It is seen that by working these chains the truck is made to travel along the rails.

This "power carriage" couples at *i* with the gun-sling carriage which travels on the trucks *h*. The two-armed lever h^1, pivoted at *h* on the axle of the forward rollers, serves as a sling for the gun in connection with the links *k* and *l*, which are fitted with removable pins to the recoil cradle at *d*, and the spring return cylinder at b^1.

The links *k* and *l*, being fitted in place, the nut h^2, fitted to revolve in the end of the long arm of the lever h^1, and in which the screw h^3 of the rear link works, is turned by hand until the weight of the gun is taken from the mount. The trunnion block a^2 (page 149, No. X) is then removed, and, the "power carriage" being set in motion, the gun is carried entirely within the port if desired.

After a little practice a gun's crew on board the *Royal Sovereign* transported one of her 6-inch R. F. guns 13 feet 3 inches inboard from

VAVASSEUR'S HOUSING APPARATUS.

Fig. 1.

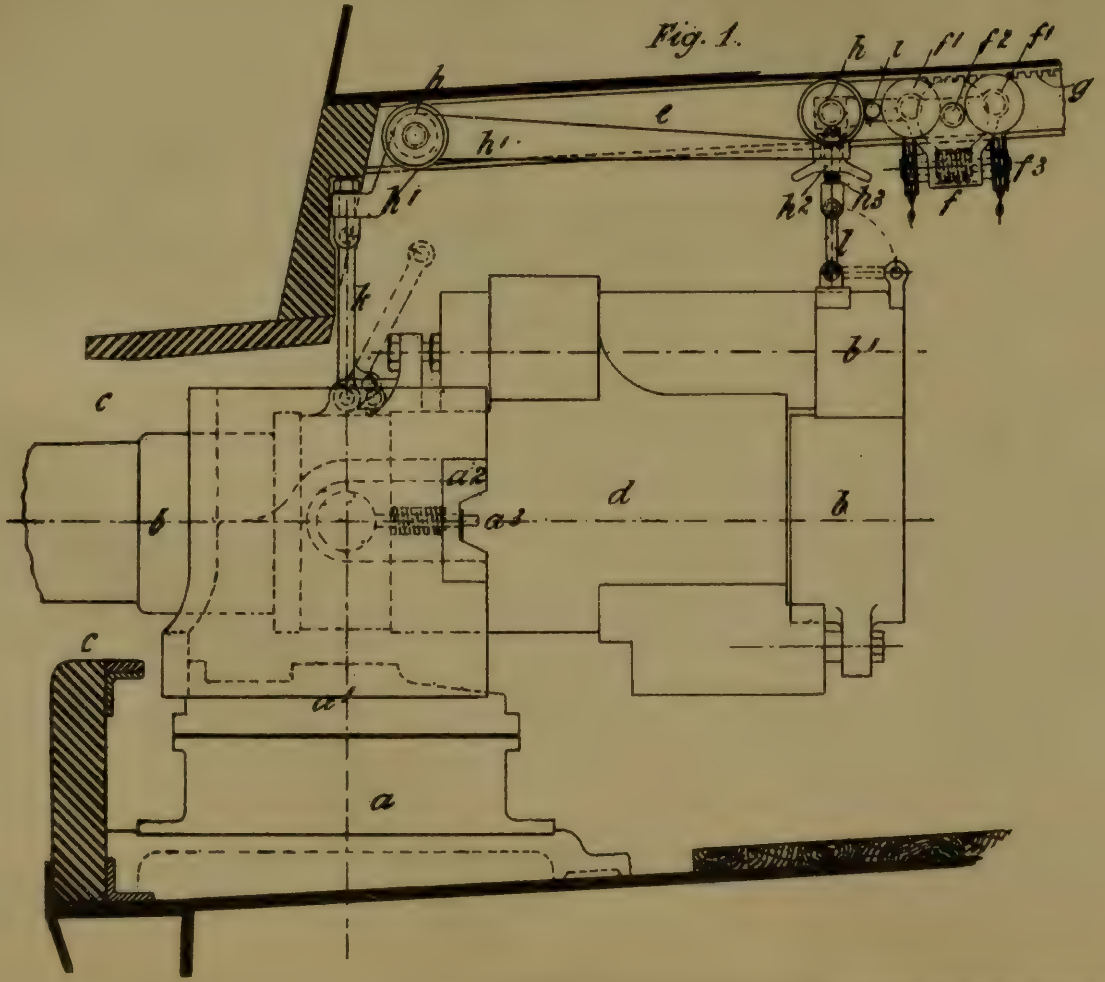
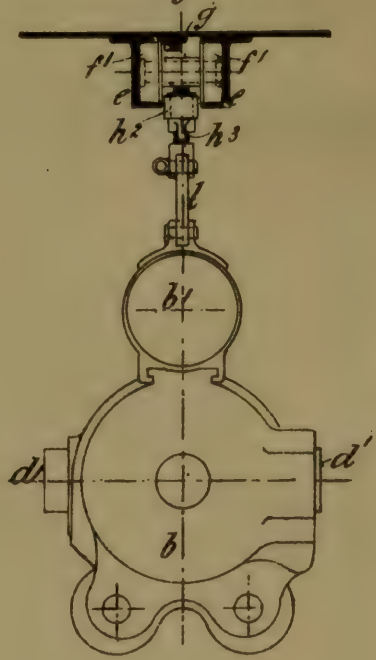
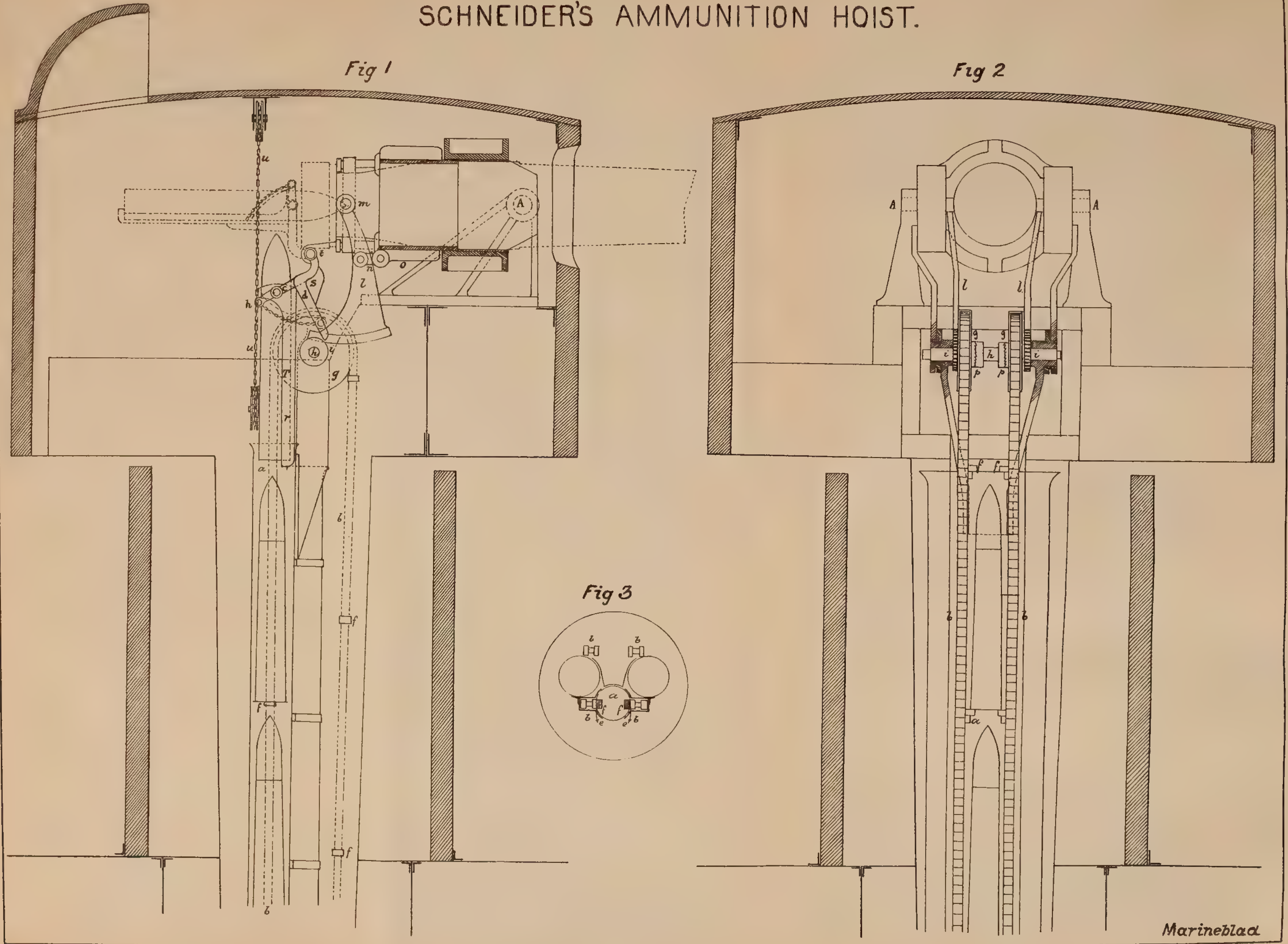


Fig. 2.



Patent Specifications

SCHNEIDER'S AMMUNITION HOIST.



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firing position in three minutes forty-two seconds, and replaced it on its mount in three minutes twelve seconds, the ship at the time being listed outboard 1° 15′.

ELSWICK PEDESTAL R. F. MOUNT.

A new type of pedestal mount, designed by the Elswick Ordnance Company for rapid-fire guns of 4.72 inches and less calibres, has been tested, and will probably be adopted for use in the British navy.

The chief objects of the mount are to simplify the number of parts vulnerable to an enemy's fire, and to do away with the use of cast-steel.

The gun trunnions fit into the fork of a vertical forged-steel pedestal, the bottom of which rests around a cone-shaped bearing on the bed plate, the weight being taken on friction balls in the cases of 20-pounder and heavier guns. The shock of firing is taken by the cone bearing, and the friction of train, with the heavier guns, by the ball bearings. The mount carries a shield, and can be trained by shoulder-piece or gearing.

During firing trials, February 5, 1892, on board the gunboat *Excellent*, using a shoulder-piece for training, the following results were obtained:

Gun, 4.72 inch R. F.; charge, 12 pounds S. P. powder; projectile, 45 pounds. Ten rounds fired at various elevations, from —3° to +16°, recoil 10 inches. Ten rounds at +20°, recoil from 10 to 10.25 inches. For rapidity of fire at target 1,200 yards distant, practice very good from a moving platform, 20 rounds in three minutes five seconds.

Gun, 12-pounder R. F.; charge, 4 pounds 10 ounces S. P. powder; projectile, 12 pounds. Ten rounds from −8° to + 20° elevation to test mount. Ten unaimed shots in 57 seconds. Ten rounds aimed at target, 1,200 yards distant, from movable platform, in one minute six seconds (target occasionally obscured by smoke). Seventeen rounds at two targets, steaming toward them, beginning at a range of 1,500 yards, in two minutes six seconds (smoke again interfering).

The mounts worked with great ease.

FRANCE.

SCHNEIDER AMMUNITION HOIST.

The question of providing a regular and efficient supply of ammunition being one of such great importance, the following description of an automatic hoist, designed by Schneider, for supplying the 30, 27, and 14^{cm} guns of the French battle ship *Charles Martel*, may prove of interest (see Pl. VII):

The two endless carrier chains *b b* (Figs. 1, 2, 3), fitted with the stop lugs *f f*, on which the projectiles seat, travel in the guide slots *b b* (Fig. 3) of the tube *a* (Figs. 1, 3) over the wheels *g g* (Figs. 1, 3). These wheels, *g g*, are free on the axle *i*, so that when the latter moves from right to left (Fig. 1) the wheels are held stationary by the chains *b b*;

but when the axle moves from left to right, the ratchet pawls *p p* couple it to the wheels, turning them with it and thus raising the projectile in the tube. This movement of the axle is accomplished automatically, by the recoil and return to battery of the gun, by the cogged sector *l*, which, swinging about the fixed pivot *m* on a band secured to the gun cradle, is actuated by the coupling *n*, movable with the gun, and gears into the cogged wheel which is fixed to the axle *i*. The tray *r*, which lifts the projectile out of the tube *a* and swings it in line with the bore, is actuated by the two-armed lever S pivoted to the gun at *t*.

The action of the mechanism is as follows:

The gun being loaded, the tray *r* is in the position shown in Fig. 1 and empty, the upper projectile being beneath the floor of the turret, as in Fig. 2. When the gun is discharged the recoil carries the arc *l* to the rear, and upon its return to battery the ratchet-pawls take and revolve the wheels *g g*, raising the endless chains *b b* until the projectile is in the position shown in Fig. 1. The endless chain *u*, shackled to the arm *c* at *h*, is then worked by hand; its first action is to raise the projectile clear of the tube *a*, at which instant the arm *d* takes under the side of the tray, when, upon further impulse of the chain *u*, the tray and levers swing about the pivot *t* until in the position shown by the dotted lines in Fig. 1. After loading, the tray is dropped into its vertical position ready to receive the next load upon the discharge of the gun. The axle *i* being secured to the gun-cradle, the whole system is elevated or lowered with the breech of the gun and therefore admits of loading in any position of train in elevation or direction.

By this system it is seen that only the required amount of ammunition is supplied, and that at no time is there an accumulation of reserve ammunition in the turret or above the tube *a*.

GERMANY.

KRUPP MOUNTS FOR R. F. GUNS.

Krupp employs both slide and cylinder mounts for rapid-fire guns of large calibres.

In the latter (see Pl. VIII, Fig. 1) the gun slides in a bronze cylinder which rests in trunnions in the carriage. The sights, being on the cylinder, do not recoil with the gun, and the training wheels bring the gun-captain close to the rear sight. The recoil cylinder is under the centre line of the gun, and contains a spring for returning the gun to battery. The recoil piston is bolted to a band around the breech of the gun.

In the slide type of carriage (Fig. 2) the upper carriage is on rollers, which facilitate its gravity return to battery after recoil; this latter is controlled by two hydraulic cylinders between the brackets. The sights recoil with the gun, necessitating the axles of the elevating and training wheels being of sufficient length to insure the gun-captain being

KRUPP R. F. GUN MOUNTS. PLATE VIII.

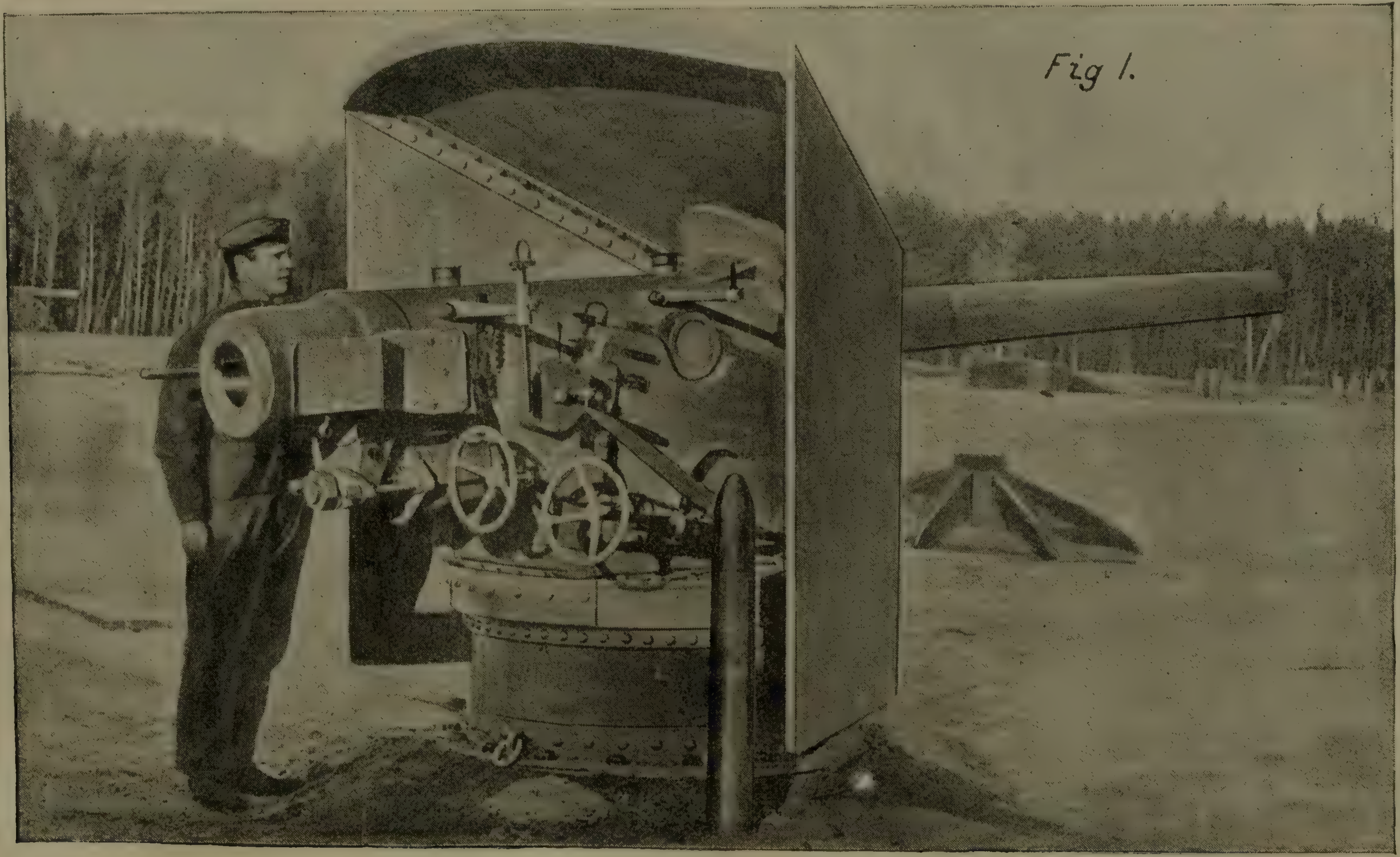


Fig 1.

CYLINDER MOUNT FOR 12^{cm}, L/40 CAL'S.

[*Revue d'Artillerie.*

KRUPP R. F. GUN MOUNTS.

PLATE VIII*a*.

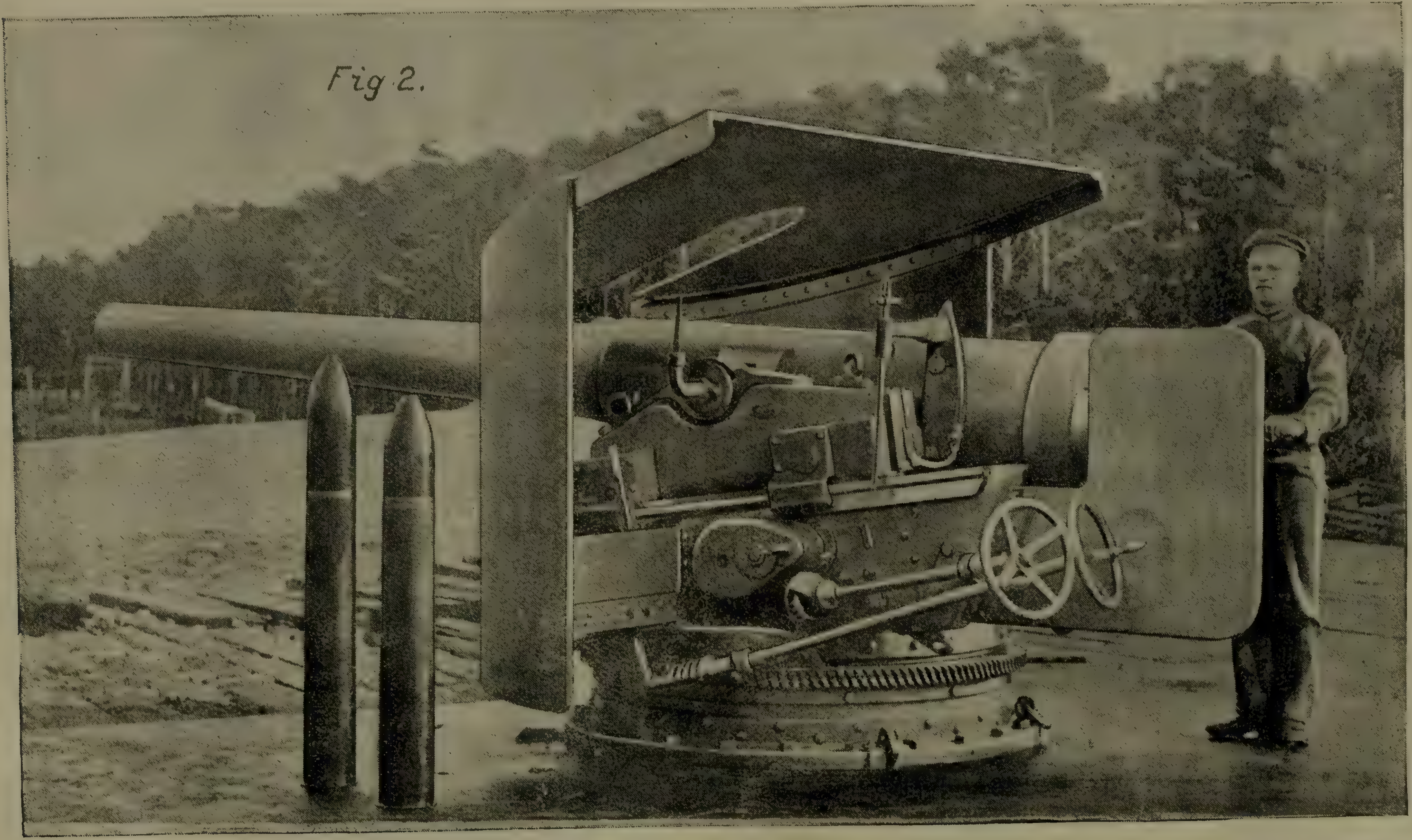


Fig 2.

SLIDE MOUNT FOR 15^{cm}. L/35 CAL'S.

[*Revue d'Artillerie.*

PLATE IX

SCHNEIDER mount for 14 c/m HONTORIA GUN

Fig. 1. Side Elevation

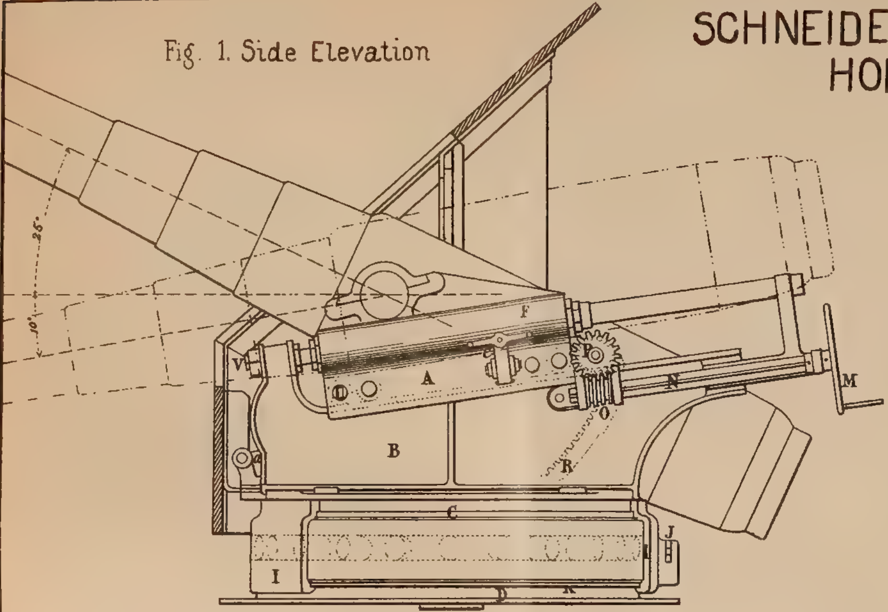


Fig. 2 Horizontal

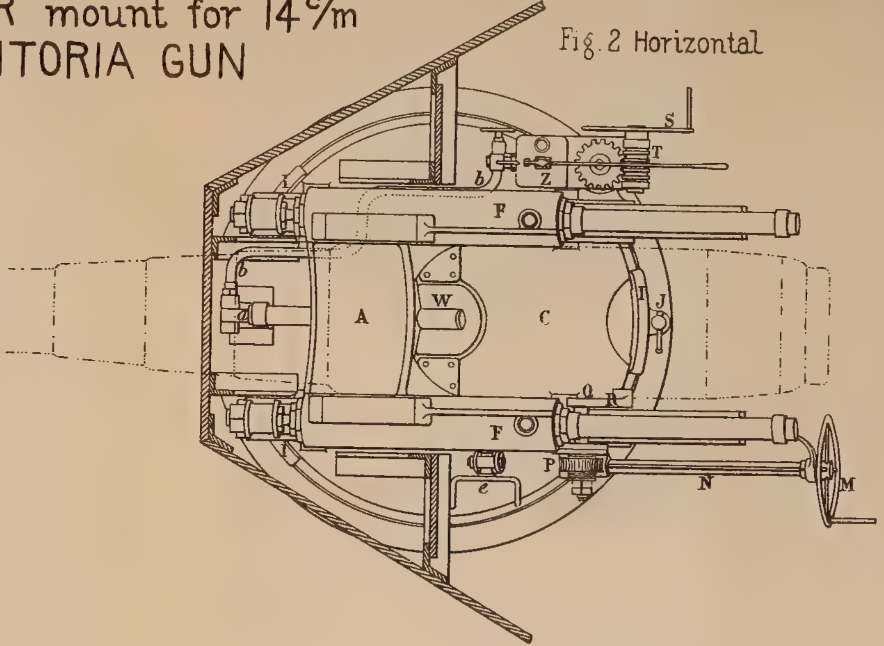


Fig. 3 Vertical Section.

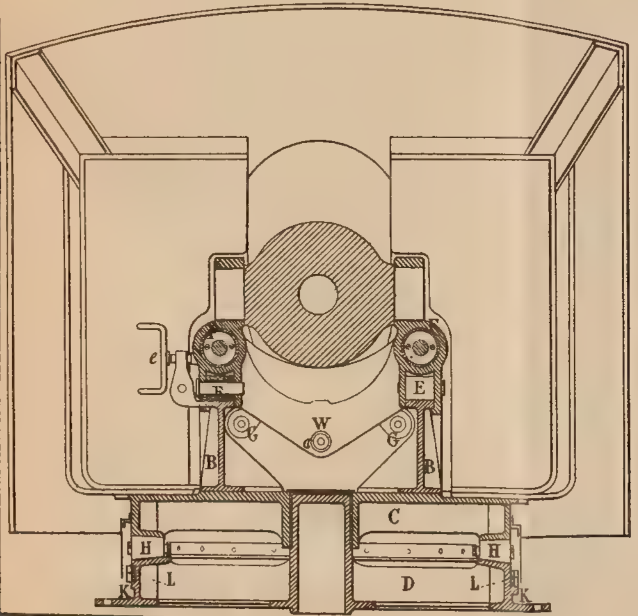
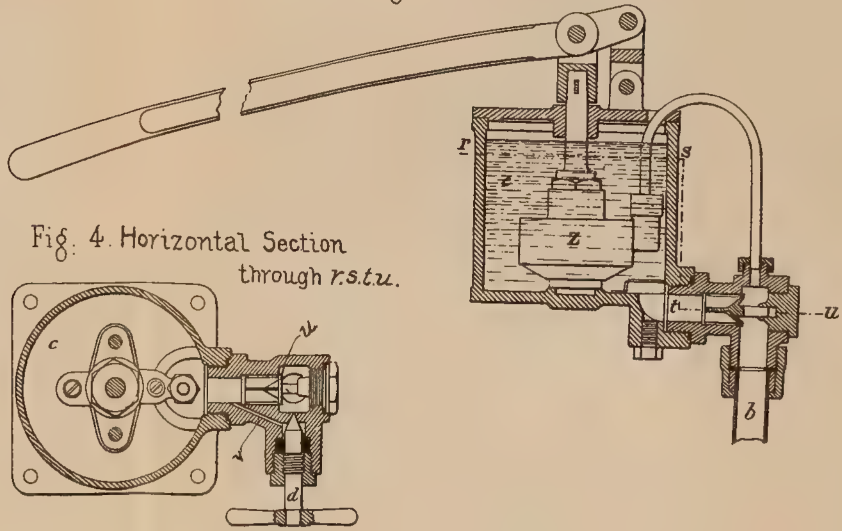


Fig. 5 Vertical Section.

Fig. 4. Horizontal Section through r.s.t.u.



Hand Control Pump

Revue d' Artillerie

beyond the distance of recoil. For running in by hand a cogged wheel on the left bracket acts on a rack of the upper carriage. A friction brake controls the return to battery.

RUSSIA.

In consequence of glycerine producing rust within recoil cylinders, its use in Russia has been stopped, and naphtha oil, which is one-third as costly, adopted in its stead.

SPAIN.

SCHNEIDER C. P. MOUNT FOR 14 CM. HONTORIA GUN.

Schneider has lately constructed hydraulic-recoil gravity-return C. P. mounts for the 14^{cm} Spanish Hontoria guns, on plans furnished by Gen. Guillen. A description of the recoil check employed, and the trial results obtained with them, will be found on page 157, No. X. The following description of the carriage will be understood by reference to Plate IX:

The gun rests in trunnions on the *upper carriage*, A, which carries the recoil cylinders F, and rests on roller E on the slide B; these rollers E are retained in position by cheeks of the upper carriage, the outer ones of which are flanged to act as clips to prevent the carriage lifting from the slide. The *slide* B is bolted to the transom C, and carries lugs V, to which are bolted the recoil pistons, and the spring buffers G to take up shock of running in or out. The elevating gear is bolted to the slide, and therefore does not recoil with the gun. The upper faces of the slides are inclined at an angle of 8°. The *transom* C, turning on the pivot, revolves on the free conical rollers H, which are retained in place by inner and outer rings; bolted to it are the clip hooks I, taking under the rim K of the bed plate to prevent the carriage lifting, and on the rear clip is the lug J for the securing bolt. The *bed plate* D, bolted to the deck, forms the pivot, and carries on its circumference the cogged rack L, in which gears the cogged wheel of the training gear. A housing socket is cut in the bed plate for the securing bolt J.

Elevating gear.—The mount admits of 25° elevation and 10° depression. The gear consists of the wheel M, arm N, endless screw O, and cogged wheel P, set with friction control, actuating the quadrant rack R on the left side of the gun. To raise the muzzle from extreme depression to extreme elevation requires seven seconds of time.

Training gear.—By means of the worm T, actuating a cog and vertical axle, the wheel S, on the right side of the gun, revolves a cog wheel geared to the rack L of the bed plate, and so turns the mount. One man can train the gun through 360° in fifty-four seconds.

Recoil check.—See page 157, No. X.

Running in by hand.—On the under side of the upper carriage A is the small cylinder W, in which is the hollow piston *a*, secured to the front of the slide B. The pipe *b* connects it with the pump Z, fitted to the right side of the carriage, and shown in detail in Figs. 4 and 5. The pump is in a box and is completely surrounded by the liquid, the system serving two purposes. (1) When it is desired to run the gun in by hand, by working the pump the liquid is forced through the small curved pipe and the pipe *b*, enters the cylinder W through the hollow piston *a*, and forces the upper carriage and gun to run in. To retain the gun run in by hydraulic power, the stem *d* (Fig. 4) is screwed into its seat, and by thus preventing the backward flow of the liquid, keeps the cylinder W full and the gun stationary. (2) The other use of the system is to control the gravity-return of the gun to action, as follows: The check valve *u* opens or closes communication between the pipe *b* and the reservoir *c*. When the gun recoils, a vacuum being produced in the cylinder W, the valve *u* lifts, and the liquid flows from the reservoir *c* into the cylinder W. When the gun returns to battery, the pressure closes the check-valve *u*, and the liquid is forced through a narrower channel *v* (Fig. 4), the flow being controlled by the screw stem *d*, thus reducing the velocity of the return.

Hand check.—Pivoted to the upper carriage is a clamp, operated by the handle *e*, which takes against the upper edge of the slide and secures the gun for sea.

The carriage is protected by a 1.18 inch steel shield mounted on it, weighing 1.8 tons. The weight of the mount, without the shield, is 3 tons.

During the trials of this mount, given on page 157, No. X, a Schneider 15^{cm} gun was used, the trunnions of which were built out to fit the mount.

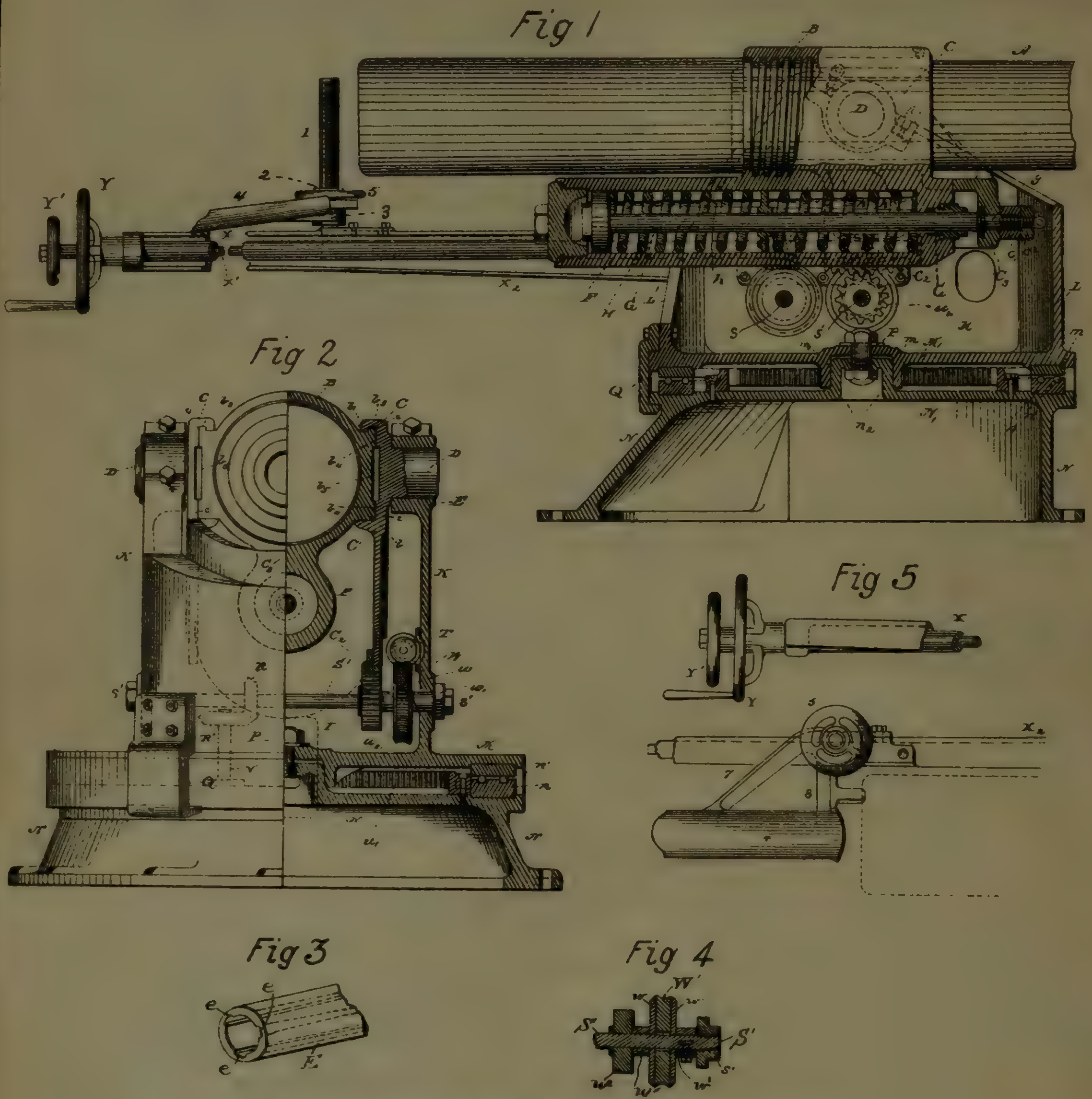
UNITED STATES.

NAVY 4-INCH R. F. GUN MOUNT.

The rapid-fire gun mount, designed by Lieut. F. F. Fletcher, U. S. Navy, and described on page 154, No. VIII, has been so modified that a description of it as finally adopted for the 4-inch rapid-fire guns is here given, reference being made to the drawings on Plate X.

Carriage.—The band B, screwed on the gun at its center of gravity, has, cast on its under side, the recoil cylinder F, and on its sides the lugs b_1, b_2, b_3 (Figs. 1 and 2). These lugs slide in corresponding recesses in the sides of the rocking frame C, which frame takes the weight of the gun, furnishes the trunnions D, and acts as the guide during recoil. The upper carriage is composed of the two side brackets K, which support the trunnions and carry the transverse axles S and S^1 of the training and elevating gear, and of the front and rear transoms L and L^1. The transoms and brackets are bolted to the base plate M,

PLATE X



FLETCHER 4 inch R.F. Gun-Mount.

which is provided on its under side with the cylindrical shoulder m^1, fitting over the central pivot n_2, and has bolted on the outside the clips Q, two in front and one in rear, which, with the bolt D, prevent the carriage from lifting. Let into the under circumference of the base plate is the ring m, resting on a double row of steel balls n^1, which fill grooves in the corresponding ring n of the pivot stand N, thus providing a ball-bearing surface for the upper carriage to revolve upon. The pivot stand N is bolted to the deck, and carries the circular rack u^1, for training in direction.

Training gear.—The training shaft X (Fig. 1), on the left side of the gun, is hollow, and works by means of the hand wheel Y, independently of the elevating shaft X^1, which is contained within it and which is manipulated by the wheel Y^1. On the front end of the shaft X is the worm T (Fig. 2), which actuates the worm-wheel W, on the rear axle S, and, through them and the pinions R and R^1, the cogged wheel (not shown) on the vertical axis v; this cogged wheel gears into the circular rack u^1, and revolves the carriage.

Elevating gear.—Cast in one with the rocking frame C is the quadrantal arm C^1, to the lower end of which is bolted the cogged arc C_2. Keyed to the forward end of the interior or elevating rod X^1 (Fig. 1), and in front of the training worm T, is a similar worm working in a worm wheel on the forward axle S^1 (Fig. 1); on this axle is the cogged wheel u_2, (Figs. 1 and 2) which, gearing in the cogged quadrant C_2, causes the gun to swing about the trunnions D, as an axis, when the hand wheel Y^1 is turned.

In order to permit of quick training without the use of gearing, and also to avoid damage from excessive strains, the worm wheels W and W^1 are loose on the shafts S and S^1, being held by frictional discs. Figure 4 shows one of these wheels, S^1 being the axle, W^1 the worm wheel, w w the friction discs, and w^1 w^1 sliding collars which hold, or are in one with the discs; w_2 is a set collar, and s^1 a screw nut. By setting up or loosening the nut, the frictional bearing of the discs may be regulated at will.

Recoil check.—The hydraulic recoil cylinder F (Fig. 1.), referred to above as being cast in one with the screw band B, contains the liquid, the piston and rod G, and the spiral spring H for return to battery. The forward end of the piston passes through a stuffing box in the cylinder, and is secured by right and left handed nuts c_1 c_2 to the front arm c_3 of the rocking frame C. The spring H is set in place with an initial tension, so that it tends constantly to force the gun into firing position. Grooves of varying cross section are cut in the interior of the cylinder (Fig. 3), by which the flow of liquid from the front to the rear of the piston, during recoil, is controlled.

Loading tray.—A loose collar 3 (Fig. 1) on the vertical screw 1, carries, by the arms 7, 8 (Fig. 5), the loading tray 4. This tray is swung clear before firing the gun, and into the position shown in figure 5 after the discharge. It is raised or lowered by the wheel 5, and nut 2, working on the screw 1, so that it can always be brought into position for loading without changing the gun's elevation.

SCHNEIDER'S RECOIL CHECK.

A new hydraulic recoil check has been invented by Schneider, and fitted to a mount for a 15^{cm} rapid-fire gun.

A longitudinal section is shown on Plate XI. T represents a trunnion of the gun, secured in its seat by the block S. CC^1 are twin hydraulic cylinders which move with the gun on recoil, sliding on the frame F. The lug L is cast on the front cylinder and serves to compress the return spring *r*, and to carry the gun back to battery after recoil. A system, such as is shown in the drawing, is on each side of the gun, so that the complete recoil is controlled by four cylinders. Each system has a trunnion seating in the bracket of the carriage, and as the elevating rack is on the left frame N, the line of recoil is always parallel to the axis of the gun.

The principal object of the four cylinders is to distribute the effects of the firing over a large number of points, and thus equalize strains.

The recoil action is as follows, the system, before firing, being in the position shown in the plate:

Upon discharge, the cylinders C, C^1 move to the rear, and the pistons P, P^1 and rods R, R^1 being held stationary in the frame F, the liquid is forced through the grooves *g g*, of varying cross section, to the rear sides of the pistons, the rate of recoil being determined by the depth of the grooves.

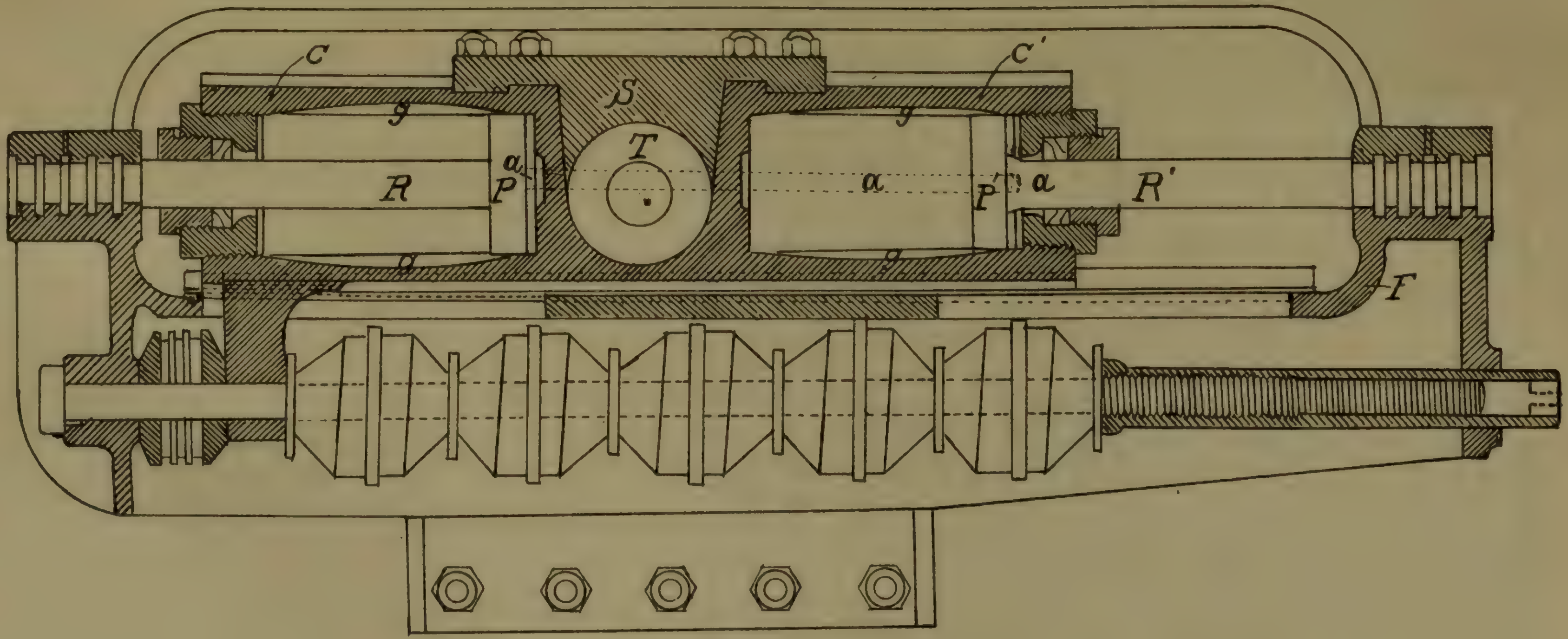
As both cylinders and pistons are of the same dimensions, the increased volume produced in rear of the front piston, by reason of the withdrawal of the rod R, is the same as the decreased volume in rear of the rear piston. A communicating side tube *a a a* connects the rear of both cylinders, and through it the overflow of liquid in the rear cylinder C^1 passes to C, and thus preserves a constant pressure in both.

The maximum recoil allowed is 9.84 inches, when the grooves are fully closed. As the gun is returned to battery by the return spring *r*, the lug L comes against the buffer B, which reduces the shock. The initial tension of the return to battery spring can be regulated by the setting up of the sleeve *h*.

This recoil check was fitted to a Schneider c. p. mount for a 15^{cm} R. F. gun, which was used as the mount of a 14^{cm} Spanish Hontoria gun during its reception firing trials. It functioned well, and, as fitted, admitted of —5° and +18 train in elevation.

PLATE XI

SCHNEIDER Recoil Check for R.F. Gun Mount.



Revista General de Marina

SMALL ARMS.

The great saving in weight of cartridge, and consequent increase of ammunition supply that can be carried per man, combined with flatness of trajectory and increased penetrations, resulting from the use of small-calibre small-arms, is leading to the adoption of still smaller calibres in the latest types of magazine rifles.

Calibres of 6.5^{mm} (.256-inch) are now adopted and in service; and Prof. Hebler, an authority on the subject, states that the difficulties of manufacture of barrels and breech mechanism of still smaller calibres have been overcome, and predicts 5^{mm} (.197-inch) as the calibre of the small arm of the future, estimating that a man can carry twice the ammunition supply for a calibre of 5^{mm} as for that of 8^{mm}.

The absence of shock of the long, narrow enveloped bullet, when not striking a vital part, may not result in immediately putting a man out of action, and may prove less effective in stopping cavalry; but the great penetrative power and range will increase the number of hits and probable efficiency. Looking toward increasing the shock of impact, Gen. Tweedle has designed a bullet having a mantlet head which mushrooms on impact and makes a large wound; and if such a projectile can be made to retain its accuracy of flight, it would seem that this deficiency in the new bullets could be overcome.

The following tables, taken from an article by Capt. W. H. James, F. R. G. S., on "Magazine Rifles, Their Latest Developments and Effects," give some interesting particulars of some of the latest small arms adopted abroad:

The latest patterns magazine rifles.

Country.	Type.*	Weight.		Caliber.	Weight of bullet.	Weight of charge (smokeless).*	Bullet covering.	Muzzle velocity.	Sighted to—	Position of magazines.	Rounds in magazines.	Cartridges in frames.	Cut-off to magazines.	Bolt action.
		Lbs.	*ozs.*	*In.*	*Grs.*	*Grs.*		*Feet.*						
Austria	Mannlicher	9	10	.315	242	42.43	Steel	1,968	2,500 paces	Central	5	Yes	No	Straight.
Belgium	Mauser	8	2	.301	219	54.00	Nickel	1,980	2,050 meters	do	5	Yes	No	Turns.
England	Lee-Metford	9	4	.303	215	69.44 (Black powder)	Alloy of nickel and copper.	2,000	2,900 yards	do	10	No	Yes	Do.
France	Lebel	9	4	.315	216	41.66	Maillechort. (An alloy of copper, nickel, and zinc.)	2,073	2,000 meters	Tube	8	No	Yes	Do.
Germany	Mannlicher	8	6	.311	223	38.58	Steel. (Plated with an alloy of copper and nickel.)	2,034	2,050 meters	Central	5	Yes	No	Do.
Italy	Carcano	8	4	.256	*231.4	34.25	Maillechort*	*2,329		do	5	Yes	No	Do.
Russia	Mouzin	9	8	.300	215	32.91	do*	2,000	2,335 yards*	do	5	Yes	No*	Do.
Switzerland	Schmidt	9	10	.295	211	30.86	Steel. (Plated with an alloy of copper and nickel.)	*2,000	2,000 meters	do	12	Yes	Yes	Straight.

Carbines.

Country.	Type.*	Weight.		Caliber.	Weight of bullet.	Weight of charge (smokeless).*	Bullet covering.	Muzzle velocity.	Sighted to—	Position of magazines.	Rounds in magazines.	Cartridges in frames.	Cut-off to magazines.	Bolt action.
Austria	Mannlicher	*7	4	.315	242	42.43	Steel	*1,902	2,400	Central	5	Yes	No	Straight.
France	Berthier			.315	216	33.00	Maillechort			do	3	Yes	No	Turns.

* Not in the original.

Showing the penetration of modern rifle bullets into various substances.

Range.	Rifle.	Materials,				
		Earth.	Deal.	Oak.	Iron.	Steel.
		Inches.	*Inches.*	*Inches.*	*Inch.*	*Inch.*
10^{m} (11 yards)	French	10	30	8	0. 47	0. 39
200^{m} (220 yards)	...do	18	24	11	0. 24	0. 16
500^{m} (550 yards)	...do	16	20	6	0. 16	0. 08
100^{m} (110 yards)	German	36	32	....	Up to 300^{m}. (330 yards) traverses 0. 28 in.	
400^{m} (440 yards)	...do	20	18	....	....	
800^{m} (880 yards)	...do	14	10	....	....	

With the English rifle the following thicknesses are considered proof at any range: Earth, 24 inches; iron or steel plate, 0.365 inch; fir, 38 inches; oak, 24 inches; one "header" or two "stretcher" sand-bags.

ARGENTINA (Mauser M/89, Calibre .301 inch).

In March, 1890, the Government of Argentina decided to adopt the Mauser, M/89, calibre .301 inch, magazine rifle (page 164, No. X). A contract was made with the Loewe Works, at Berlin, for 100,000 rifles and 20,000 carbines, at a cost of $16.40 apiece; after the delay caused by increasing the plant to the required capacity, 30,000 rifles are now ready for delivery. The Remington single-fire rifles are still in service aboard their newest vessels.

AUSTRIA.

MANNLICHER (Model 1886–'90).

Orders have been issued to turn in the 90,000 Mannlicher 11^{mm} M/86, repeating rifles, acquired by the Government up to 1887, and they are to be converted into calibre 8^{mm}, M/86–90, to receive the new smokeless powder cartridge, model 1890.

MANNLICHER CARBINE (Model 1890).

The new Mannlicher 8^{mm} repeating carbine, M/90, for which preparations looking toward its adoption were begun in May, 1890, was definitely adopted September, 1891.

It is designed to use the same ammunition, M/90, as the infantry Mannlicher, M/88 (page 403, No. VIII), and although the bolt movement is similar to it, the arrangement of the parts is so different that the following description may prove of interest, in which reference is made to Pl. XII.

The breech box A (Fig. 1), into which the barrel is screwed, contains the locking recesses *f f′*, and is mortised to contain the several parts. It is securely assembled to the stock by the recoil tenon *h*, screw lug *k*, and reënforce *m*. The magazine box differs from that in the model of 1888, by being in one with the trigger guard, which is secured to the rear top plate *n* of the breech mechanism by the through screw *l′*.

The trigger mechanism (Fig. 2) comprises, (1) the elbow trigger B, working about a bearing edge, γ, and fitted with two lugs, δ (Fig. 7), which act as stops to the rearward travel of the bolt by taking against the lugs p (Fig. 3); (2) the tumbler C (Figs. 1, 2, 5, 6) pivoted at e, fitted to contain the cocking beak s, pivoted at e, and sear and ejector spring t, and the ejector D pivoted at e_1; the front head a_1, acting in conjunction with the tenon b of the bolt, forms the safety latch until the bolt is locked; the toe piece r serves to hold the trigger B in place.

The bolt (Figs. 1, 2, 3 4,) comprises the cylinder F; bolt handle G, carrying the safety pawl H; movable head I, with its shaft J; firing pin M, with its thumbscrew N; mainspring and extractor x.

The outside of the cylinder is fitted with guide lugs u, stop lugs pp, and safety tenon b, hollowed to seat the ejector head when the breech is closed. It contains the shaft J of the movable head, which is spirally grooved to fit the rifle lands v in the cylinder. The pin λ secures the stop ring w in place, and its end fitting into a longitudinal groove (dotted in Figs. 1 and 2) of the firing pin, prevents the latter from turning. The right side of the cylinder is hollowed out to contain the extractor θ.

The movable head I and its shaft J, which contains the firing pin and mainspring and is closed at its rear end by the plug K, is fitted at its front end with two locking lugs which engage in the chamber slots ff'. The exterior surface of J is spirally grooved, y, into which grooves fit the lands v of the cylinder; y_1 and y_2 are slits cut to receive the beveled hook θ of the extractor.

The extractor x fits around the movable head in front, and is thinned near its rear end to allow the beveled hook θ to spring up out of the slit y_1 over the shaft J and seat in y_2, when the initial movement of the bolt performs the function of revolving the head. It is thus seen that the extractor does not revolve with the head, but only partakes of the movement of translation.

The magazine and feed are similar to those in the Mannlicher, M/88, except that the cartridge elevator is simpler, consisting now of one arm and spring.

Action of the piece.—From the above description it will be seen that the first movement to the rear of the bolt handle (0.79 inch) and cylinder, causes the head to revolve from right to left 90°, and thus release the locking lugs from the chamber slots $f f'$. This movement draws the firing pin to the rear, it being locked in cocking position by the lugs I moving into their guide grooves in the breech box. The bolt is pulled to the rear until its movement is stopped by the lugs p p, and the rim of the empty cartridge case taking sharply against the head of the ejector D, it is thrown out. When the bolt is pushed forward the dog q of the firing pin takes against the trigger beak s, before the bolt-head lugs commence to turn in the chamber, and the firing pin is thus held back at full cock. The head a_1 of the tumbler C is held down by

AUSTRIAN MAGAZINE CARBINE (Mannlicher m/90)

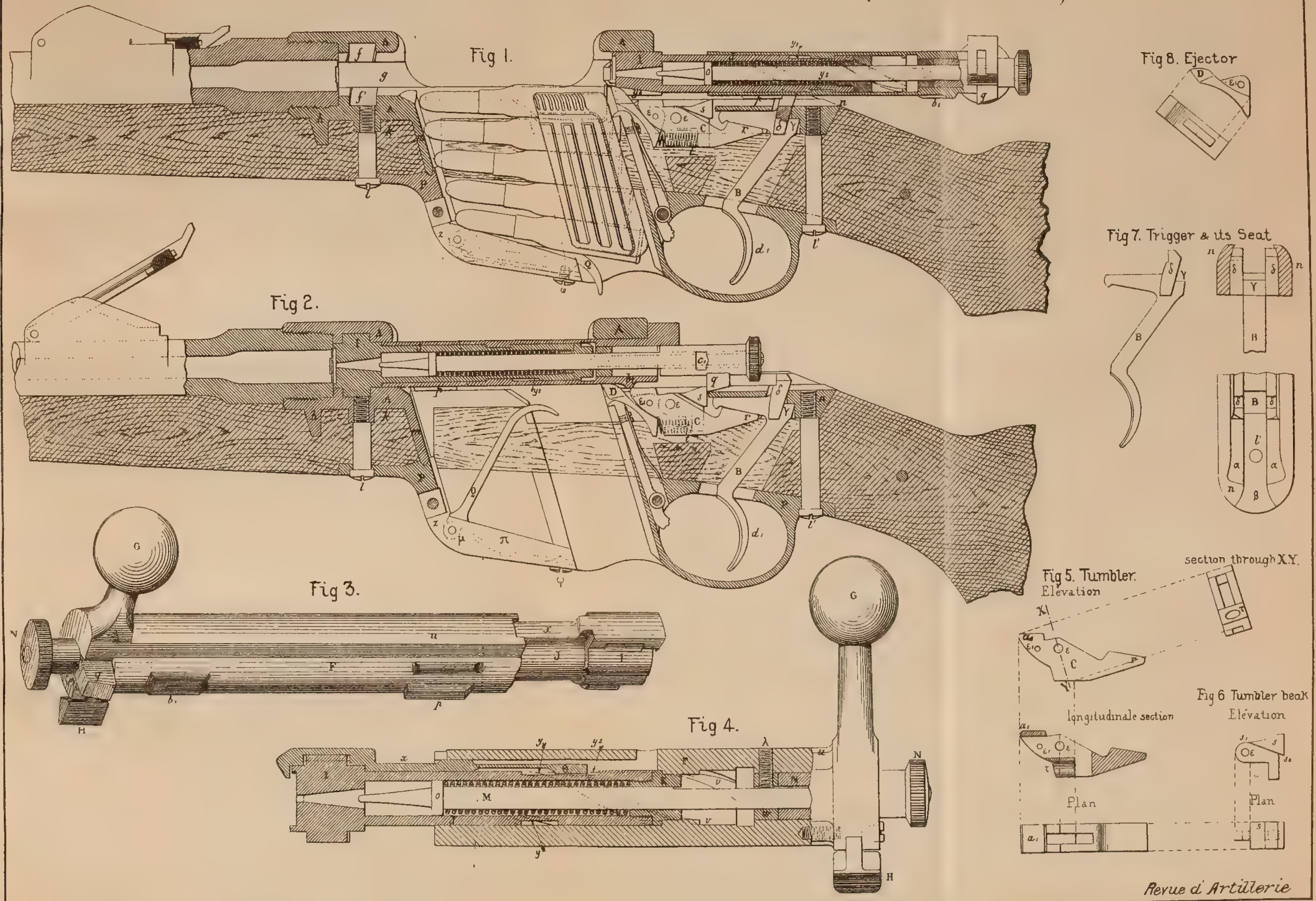


Fig 1.

Fig 2.

Fig 3.

Fig 4.

Fig 5. Tumbler.

Fig 6 Tumbler beak

Fig 7. Trigger & its Seat

Fig 8. Ejector

Revue d'Artillerie

the safety lug *b* of the cylinder, until the final movement of locking, when it just clears and allows the trigger to release *s* from *q* at will.

In comparison with the infantry rifle M/88 (page 403, No. VIII), we find this carbine to possess the following advantages: (1) Stronger chamber; (2) locking studs in front head of bolt, constituting another element of strength; (3) more compact; and (4) simpler feeding arrangement.

Following are the data of this arm and ammunition:

Data of carbine.

Length	inches	39.6
Weight	pounds	7.25
Barrel:		
Calibre (8$^{\text{mm}}$)	inch	.315
Length	do	19.61
Grooves:		
Number		4
Depth	inch	.008
Width	do	.138
Lands, width	do	.086
Rifling twist		5° 44′ 26″
Thickness of walls:		
Muzzle	inch	.138
Breech	do	.33
Bolt		straight pull

Data of ammunition.

Cartridge, model 1890:		
Weight	grains	455.2
Length	inches	2.99
Cartridge case:		
Weight	grains	166.6
Length	inches	2.05
Charge:		
Kind	rifle	M/90
Weight	grains	42.43
Bullet:		
Material		hardened lead
Envelope		steel
Weight	grains	243.8
Greatest diameter	inch	.323
Length	inches	1.25
Initial velocity	f. s.	1,902
Perforation at 15 paces		18.1 inches beech wood.

For diminishing weight a substitute for brass for cartridge shells is being searched after, such as aluminium or other light metal.

BULGARIA (Mannlicher M/88, Calibre, 8 mm.).

The Bulgarian Government has ordered 50,000 rifles and 6,000 carbines from the Austrian small-arms factory at Steyr. These, with the 90,000 rifles previously delivered, will complete the armament of her army with a modern small-calibre arm.

CHILE (Mannlicher M/88, Calibre, 8 mm.).

Chile is said to possess 25,000 Mannlicher rifles, M/88, calibre 8^{mm}. From accounts which have appeared in public prints, we gather that during the battles of Concon and Placilla many of these rifles were in use, and are reported to have handled easily and with good precision. In one engagement, in which 35 per cent of the combatants were armed with them, 56 per cent of the wounds inflicted are said to have been by them. Casualties to the guns, principally from barrels bursting, amounted to 7 or 8 per cent after firing 160 to 200 rounds. Men in the rear rank were often struck by bullets that had passed through the man in front of them; and although the attainable range was 2,734 yards, it was seldom utilized at over 1,750 yards, at which distance considerable execution was done. Volley firing at 1,100 yards was very effective.

It seems to be acknowledged that wounds inflicted by these rifles either killed at once, or were so clean and small that a rapid recovery followed. Mortal wounds were few in comparison with those inflicted with the large calibre lead bullets of the Gras, Comblain, and Colt rifles.

CHINA (Lee, Calibre, .433 inch).

The investigations in China in search of a modern small-arm have reduced themselves to a choice between the English Lee-Improved and the Austrian Mannlicher.

They already possess 50,000 of the former type, calibre, 11^{mm} (.433 inch); but the final decision of the Commission, placing a new order, has not been made as yet.

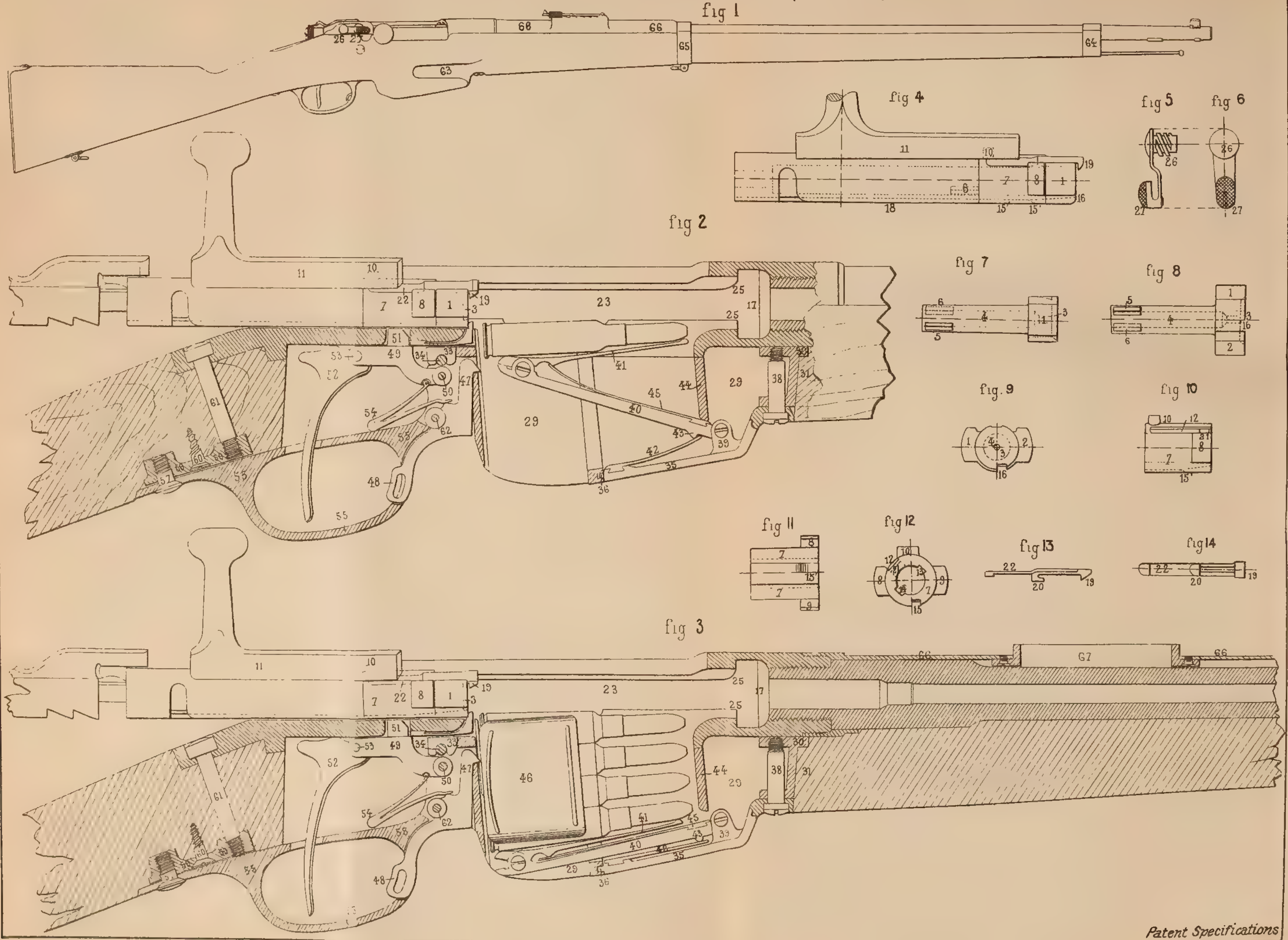
ENGLAND (Lee Improved, Caliber, .303 inch).

Mark I.—About 300,000 small arms of this type (page 128, No. IX) have been completed and are in service or ready for issue. Those in service last year were of the original pattern, but orders were issued this spring to turn them into store to be replaced by others of the same type which have been sighted for use with Cordite ammunition, and in which the mainsprings have been improved in manufacture, and the magazine springs also improved.

The Secretary of State for War states that during experiments to test the maximum range of this rifle, the mean of a group of shots gave an average range of 3,500 yards, and that the longest range attained was 3,700 yards.

Mark II.—A limited number of rifles of this type, which include the modifications mentioned on page 161, No. X, were manufactured at the Government factory at Enfield, and passed successful tests. The bolt-head alteration is stated to constitute an undoubted improvement. Their manufacture for service was begun in December, 1891.

FRENCH MAGAZINE CARBINE (Berthier)



Patent Specifications

Martini-Henry.—It is proposed to convert the Martini-Henry carbines to a calibre of .303 inch, to use the same ammunition as the infantry rifle.

FRANCE (Berthier, Calibre, .301 inch).

This rifle, which bears the name of its inventor, has been adopted as the cavalry carbine, and will probably become the French military arm at an early date. The Hotchkiss Ordnance Company has acquired the patent rights outside of France, and has employed M. Berthier. Eighty thousand carbines are being manufactured for the French cavalry.

The rifle is illustrated in Plate XIII.

It is a bolt gun with a box magazine capable of containing four cartridges. The interior mechanism of the bolt, including the cocking arrangement, bolt lever, firing pin, and spiral mainspring, is similar to that of the Lebel M/86, described on page 370, No. VII. The other parts, relating to the breech and repeating mechanism, may be understood by the following description and drawings:

Breech bolt.—This carries on its front end the movable head (Figs. 7, 8, 9) recessed, 3, to contain the base of the cartridge, and provided with the locking lugs 1, 2. The body 4 is cylindrical, and is fitted with the two rotating studs 5, 6, which slide through the grooves 14, 15 (Fig. 12), of the locking sleeve 7 (Figs. 10, 11, 12), and fit into grooves in the bolt cylinder so as to rotate the head when the bolt lever is turned. This sleeve 7 is made with two guide lugs, 8, 9, on its front end, of the same size as the locking lugs of the movable head, 1, 2, and is a neat fit over the body of the movable head; the lug 10 on its rear end fitting into an L-shaped mortise in the bolt cylinder 11 serves to communicate movement of translation to the sleeve when the bolt handle is vertical. When the guide lugs, 8, 9, are in the guides, 23, 24 (Figs. 2, 3), the head rotating studs, 5, 6, are not in line with the sleeve grooves 13, 14, but abut the rear face of the sleeve, and thus lock the head and cylinder after they have been introduced into the cylinder chamber.

A groove, 15 (Fig. 12) and 16 (Figs. 8, 9), is cut in the sleeve and head in the prolongation of a shallower straight groove, 18 (Fig. 4), of the bolt cylinder, to give passage to the head of the tumbler, 51 (Figs. 2, 3), which engages in the notch of the trigger-dog. The forward end is narrowed and sloping, and allows only free passage to the ejector. The rearward movement of the breech-bolt is limited by the spring-lever screw, 26 (Figs. 1, 5, 6), working in a screw-hole in the right wall of the breech-box.

The extractor (Figs. 13, 14) is made with an extracting-hook end, 19, and has near the middle a hook, 20, which enters the recess, 21, of the sleeve, and acts as a pivot. The rear end, 22, is a spring fitting into the groove, 12, of the sleeve, and is held in position by being under the reinforce, 11 (Fig. 4), of the bolt cylinder.

The ejector, 62 (Fig. 2), is a spring plate dovetailed under the rear part of the breech chamber. During the forward and rearward movement of the breech bolt its head remains under pressure in the groove, 18 (Fig. 4), of the bolt, until the latter reaches the end of its rearward movement, when it travels up the inclined slope, 15′ (Fig. 10), and comes against the extracted cartridge, throwing it out by the shock.

To assemble.—The sleeve is placed on the movable head, and the extractor fitted in place. The rotating lugs, 5, 6, are then slid into their grooves in the breech-bolt cylinder, and the sleeve turned about the head until the lug, 10, is seated in the end of its mortise in the reinforce, 11. The locking lugs, 1, 2, will then be next to the guide lugs, 8, 9, and the bolt cylinder is entered in the chamber with these lugs traveling in the guides, 23, 24, as in Figs. 2 and 3. The spring stop-screw, 26, is then set into place.

The action is as follows: The bolt is pushed forward until the locking lugs, 1, 2, enter the breech chamber of the barrel; turn the lever to the right and the guide lugs 8, 9, being held in their guides, 23, 24, keep the sleeve stationary, and consequently the extractor, while the head revolves and the locking lugs, 1, 2, take in the chamber slot and thus lock the bolt at its forward end. The guide lugs, 8, 9, close the guide grooves, 23, 24, against any possible back-blast from a defective cartridge.

From the above it is seen that this system of breech closure has the two great advantages of locking the bolt at its front end, and also of having the extractor devoid of a revolving movement which would necessitate enlarging the bore chamber, and also be apt to injure the cartridge case.

To dismount the breech bolt.—Loosen the spring screw, 26, a half a turn, press the trigger back to lower the lug, 51, and draw the breech bolt out to the rear.

Repeating mechanism.—This includes the magazine and the front and rear mechanisms.

Magazine.—Figs. 2 and 3 show the magazine assembled with the gun; it is a trapezoidal box introduced from the upper side, having a front lug, 30, resting on the wood of the stock, 31, and with two curved lugs at its rear end, 33, which seat on the through-pin, 34. It receives the charging packets and front mechanism.

Front mechanism.—This is carried on the plate, 35, which is secured to the magazine box by the tenon, 36, and screw, 38. It consists of the lever arms, 40, 41, pivoted to each other, and to the plate, 35, at 39, which being actuated by the tension of the flat springs, 42, 45, dovetailed respectively into 35 and 40, act as the cartridge elevator. The springs are limited in their action by the arm, 40, abutting the projection, 44, and the arms, 40 and 41, coming into contact at their short ends. When this occurs, the last cartridge in the magazine is in position for charging, as shown in Fig. 2.

The working of this front mechanism is as follows: A packet charger is introduced from above and pushed down, against the pressure of the springs, 42, 45, until the clip hook, 47, catches and prevents its rising. The bolt, when pushed forward, takes against the base of the upper cartridge and pushes it into the breech. When the bolt is drawn to the rear the extractor draws the empty cartridge case with it until it strikes sharply against the ejector, 62, and is thrown out. The next cartridge then rises to the position for charging on the next forward motion; this is repeated for all four, when the charger falls out of the piece by its own weight. Upon first loading, a cartridge is introduced by hand into the breech, and the top cartridge of the fully charged magazine pressed down until the bolt passes over it, thus securing an additional round in the piece.

To use the piece as a single loader it is only necessary to open the breech and place a cartridge on the upper arm, 41, the magazine containing no charging packet.

Rear mechanism.—This includes the trigger arrangements and the clip hook, 47, of the charger. The tumbler, 49, pivoted at 50, carries the lug, 51, which holds back the firing pin at full or safety cock against the action of its spiral spring; it is held up by the tension of the double-armed spring, 54, and is acted upon by the trigger, pivoted to it at 53. The short arm, 50, of this double-armed spring, 54, presses on a projection above and a little forward of the pivot, 62, of the charger clip-hook, holding it down and thus retaining the charger in position against the upward tension of the springs, 42, 45. The trigger guard is hollowed out to receive the knob, 48, of the charger clip-hook lever.

Should it be desired to remove a loaded charger, it is only necessary to open the breech bolt and push forward the knob, 48; this detaches the hook, 47, and the charger, with its cartridges, is forced up and out of the magazine by the *front mechanism.*

The simplicity of this arm is apparent from the above description. It contains in all forty parts, eight of which make up the breech mechanism, which, containing no screws, can be readily dismounted and cleaned by the soldier without the use of tools. It has passed very successful tests, and in rough-usage trials withstood the severe experiment of firing a balistite cartridge while the bore was jammed with another bullet, without injury to the breech mechanism. Its rapidity of aimed fire is 28 rounds per minute with the rifle, and 30 rounds a minute with the carbine, in which the magazine holds 3 cartridges. Its price is stated at $19.50. The magazine chargers are inexpensive, costing about 1 cent apiece, and can be expended.

Following are particulars of rifle, cartridge, and ballistics:

Rifle:

Calibre	inch	0.301
Diameter to bottom of rifling	do	0.313
Rifling, 1 turn in	do	9.45
Number of grooves		4

The breadth of the grooves is double that of the lands.

Cartridge:		
Diameter of bullet	inch	0.308
Length of bullet	do	1.142
Total weight of cartridge	grains	380
Weight of bullet	do	205
Thickness of envelope (white metal)	inch	0.02
Weight capped case	grains	142
Weight powder (smokeless) charge	do	33
Mean muzzle velocity	f. s.	2,971
Pressure in powder chamber, per square inch	tons	14
Penetration of elm at 60 yards	inches	25
Penetration of mild steel plate (portion of machine gun shield), at 150 yards from the muzzle	inch	$\frac{7}{32}$
Correct targets were made at the following ranges and elevations:		
200 yards		0°
500 yards		40′
1,000 yards		1° 30′
Efficient range	yards	3,300

The number of rounds carried per man has been increased from 112 to 120 in the French army.

GERMANY (Männlicher M / 88, Calibre .311 inch).

The German Männlicher (page 129, No. IX) is now supplied to the whole of the active army, and a sufficient number of rifles are on hand to provide the mobilized army and second line.

The casualties mentioned (page 162, No. X) seem to have been due entirely to defective powder and not to faulty mechanism. The enormous chamber pressure of 21 tons per square inch, developed by the German smokeless powder, was excessive; and, as an example of its heating qualities, an English service paper states that out of 4,000 troops only 500 managed to fire 10 consecutive rounds.

This latter effect may, however, be due in part to the mantlet over the barrel, which we believe to be of questionable value.

GREECE.

Trials lately conducted at Athens with various magazine rifles have resulted in favor of the Männlicher, calibre 6.5^{mm}, recently adopted by Roumania. It is stated that the Greek Government will shortly adopt this arm.

HOLLAND.

The Männlicher 6.5^{mm} calibre rifle has also been selected by a Commission in Holland, and a trial of 100 of these arms will soon be made, looking toward its adoption into service.

ITALY (Carcano, Calibre 6.5^{mm}, .256 inch).

Since January, 1890, the Italians have been searching for a new arm to replace the Vitali-Vetterli, which is considered obsolete and defective. The calibre, length of barrel, system of rifling, and Männlicher magazine have been decided upon, but the bolt system which is new in design and the invention of the Commission, after examining the different modern types, is still being subjected to slight changes suggested during firing trials in the hands of six regiments. It is said to be somewhat similar to the Männlicher, M / 90 (adopted by Roumania), and has movements of translation and rotation.

After deciding upon the principal features, the Commission put them in Männlicher's hands to develop, and he produced a rifle which passed good trials in Austria, of which a few were made for test purposes at Turin and are known as the *Turino* type. Another type known as the *Carcano* was developed on the same features at the Government Works at Terni, which has shown the better results at the Netturno Firing Grounds, where firings are being conducted up to 1,970 yards. The greatest trouble has been experienced in getting an efficient extractor. A No. 3 type of rifle is now being given to the troops to experiment with, which is popularly named the *Männlicher-Carcano*.

Following are some data of the arm and ammunition:

Calibre (6.5 mm)	inches	.256
Weight	pounds	8.5
Length without bayonet	inches	48.2
Length of barrel	do	28.74
Length of line of sight	do	23.35
Length of chamber	do	2.99
Grooves:		
Number of		4
Depth of	inches	.006
Rifling, one turn in	do	7.87
Cartridge (rimless):		
Weight	grains	331.75
Length	inches	2.22
Charge:		
Kind		Balistite
Weight	grains	34.25
Bullet (lead, antimony, and tin):		
Weight	do	231.4
Length	inches	1.24
Envelope (copper, zinc, and nickel)		Maillechort
Initial velocity:		
Smokeless powder (Balistite)	f. s.	2,329
Black powder	do	1,968
Number of rounds:		
In magazine		5
Carried per man		150
Range, effective	yards	4,373
Penetration		iron .23 inch steel .16 inch

The budget for 1891–'92 appropriated $800,000 for the introduction of 50,000 rifles up to June, 1892, after which date 100,000 were to be supplied per year. But owing to delays in developing a thoroughly satisfactory arm, and for financial reasons, the manufacture will not be hurried, and it is believed that not more than 25,000 rifles will be put into service this year.

The estimated cost to change the entire armament is $24,000,000.

ROUMANIA (Mannlicher M/91, Calibre 6.5^{mm}, .258 inch).

The Roumanian Government has definitely adopted the Mannlicher, M/91, calibre 6.5^{mm} magazine rifle. A draft of a contract has been made with the small arms factory at Steyr to include the delivery of 100,000 rifles during 1892, and 120,000 in 1893; but in the meantime, before the money is appropriated, 5,000 rifles have been ordered, which will be put into service for trial purposes.

This rifle resembles both the German and Austrian Mannlichers M/88 (pages 403, No. VIII, and 129, No. IX), in action, being more like the former in appearance and in the turning-down movement of the bolt handle. Compared with it, the locking studs are stronger, and the ejector is so modified that the weakening slot in the bolt head stud is not now necessary. The barrel is shorter than in the Austrian model, and is strengthened by a jacket about 6 inches long. The mantlet is dispensed with, and in its stead is a wooden hand-guard over the barrel extending from the breech bolt to the middle band. The wooden stock extends to the muzzle.

The magazine contains five cartridges, and is similar to that in the Austrian carbine, M/90, described above. The charging packets are cut away on the sides for lightness, and drop out automatically when empty.

An initial velocity of 2,300 f. s. is expected to be developed, but the smokeless powder to be used has not yet been decided upon. Each soldier is to carry 250 rounds of ammunition.

For the purpose of reducing friction and wear of the barrel, Col. Rubin, of the Swiss Government laboratory, is reported to have invented a specially prepared oleaginous paper covering for steel-enveloped bullets, which reduces wear yet takes the rifling satisfactorily. It is stated that these cartridges are to be used in the 5,000 new rifles ordered by Roumania.

RUSSIA (Mouzin, Calibre 7.62^{mm}, .300 inch).

No full description of the new magazine rifle adopted by Russia has as yet been published, owing to the slight changes which are being made in it as defects develop during manufacture.

It is believed to be a slightly modified form of the Nagant rifle, in which the breech bolt has two motions, those of translation and rotation. The magazine is of the fixed-box type under the breech, containing a spring to feed the cartridges, and fitted with a catch to release the bottom which opens to empty the magazine. It contains five cartridges and has no cut-off. The charger packets do not enter the magazine box, but are used to convey the cartridges into position over the magazine, into which they are pushed by the thumb, as in the Mauser, M/89.

The smokeless powder, invented by a Russian and made at the Ochta and Kazan factories, is to be used in this rifle. It is stated that 70,000,000 cartridges have also been ordered from France to be delivered this spring.

Following are some details of this arm and ammunition:

Calibre (7.62^{mm})	inches	.300
Weight	pounds	9
Length with bayonet	inches	68
Rifling, one turn in	calibres	30
Grooves, number of		4
Initial velocity	f. s	2,001–2,034
Range	yards	3,888
Range, sighted for	do	2,335
Cartridge, weight	grains	362
Bullet:		
Kind		Lead and antimony
Envelope		Maillchort
Weight	grains	213.86
Length	calibres	4
No grease or lubricating paper.		
Charge:		
Kind		Smokeless powder
Weight	grains	32.91

The number of rifles required to supply the entire army, 1,790,000, are expected to be delivered by July, 1894, by the following firms, where the manufacture is now in progress: Russian factory at Tula, 230,000 annually; Russian factory at Ishevsk, 150,000 annually; Russian factory at Sjestrovezk, 50,000 annually; private factory at Chatellerault, France, 500,000 in all.

The factory at Ishevsk is to be enlarged to a capacity of an annual output of 600,000 barrels.

Twelve million dollars have been appropriated for the year's expenses.

SPAIN (improved Mauser, Calibre 7.5^{mm}, .295 inch).

After extensive trials with various models of small calibre magazine rifles, the Spanish Commission decided on the Mauser type, and purchased 2,000 rifles with their ammunition, of 7.5^{mm} and 6.5^{mm} calibres, which were subjected to service tests by two regiments. These trials have resulted in the selection and adoption of 7.5^{mm} as the calibre of the new service arm.

The rifles to be ordered, variously stated at from 100,000 to 200,000 in number, are to be manufactured at the Oviedo Works in Spain, and, it is said, under the superintendence of Mr. Mauser. A guard is added to these rifles to protect the hand from the heated barrel during rapid firing. Smokeless powder of Spanish manufacture is to be employed.

Two of the latest Spanish vessels are supplied with these small-arms.

TURKEY.

In 1890 the Turks adopted the improved Mauser, calibre 7.65^{mm} (.301 inch) without the mantlet, which are now being delivered by the Loewe Works in Germany. The magazine contains five cartridges.

According to the *Revue Militaire de l'Etranger*, the Turkish Government possessed, December, 1891, 450,000 Mausers (calibres 7.65^{mm} and 9.5^{mm}), 550,000 Martini-Henrys (calibre 11.3.^{mm}), 250,000 Remingtons, Winchesters, and Sniders (calibres 11^{mm} and 12^{mm}).

Steps are to be taken to reduce all to a calibre of 7.65^{mm}, and M. Berthier, of the Gravelot Works in France, is negotiating to convert the Martini-Henrys into magazine guns.

TORPEDOES.

The year's developments in this branch are marked by extensive experiments to increase the efficiency of the Sims-Edison dirigible torpedo; further improvements in the Whitehead type; successful runs of the Howell; and experiments with the Ericsson submarine gun.

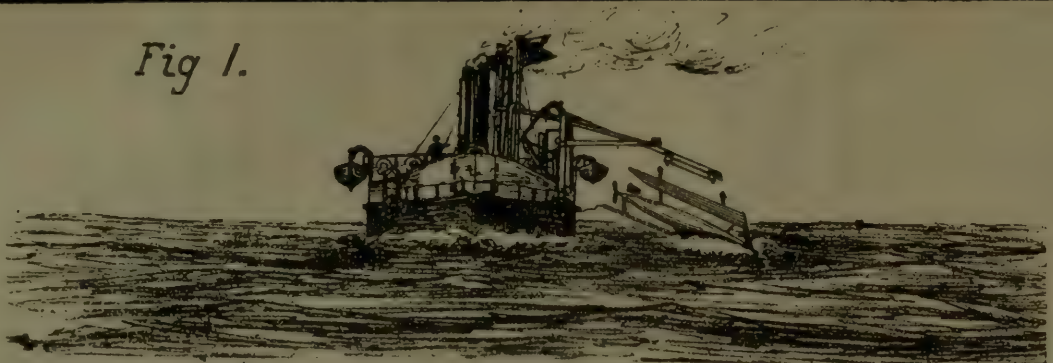
SIMS-EDISON DIRIGIBLE TORPEDO.

The Sims-Edison dirigible torpedo, the principle of which is described on page 41, No. VI, and of which mention is made on page 178, No. X, of trials conducted in France, has been adopted by the U. S. Army for coast defense, and the purchase of one for instruction and practice purposes at the U. S. Naval Torpedo Station has been recommended.

The army reception trial was conducted at Willets Point, August 12, 1891. The torpedo was 31 feet long and 25 inches diameter, carried 2 miles of cable, and had a capacity for an explosive charge of 500 pounds. It was manœuvred at will, and attained a speed of 20 knots, being 2 knots in excess of that called for by contract. Since its acceptance, however, it is stated that this torpedo has failed to perform satisfactorily, seldom running a mile without a breakdown, and never developing over 17 knots speed, and that over only short distances. The cause of these failures is attributed to insufficient insulation in the cable between the central steering wire and the outer motor wire, the currents crossing and rendering the torpedo unmanageable. It is hoped to overcome these defects by using a new cable.

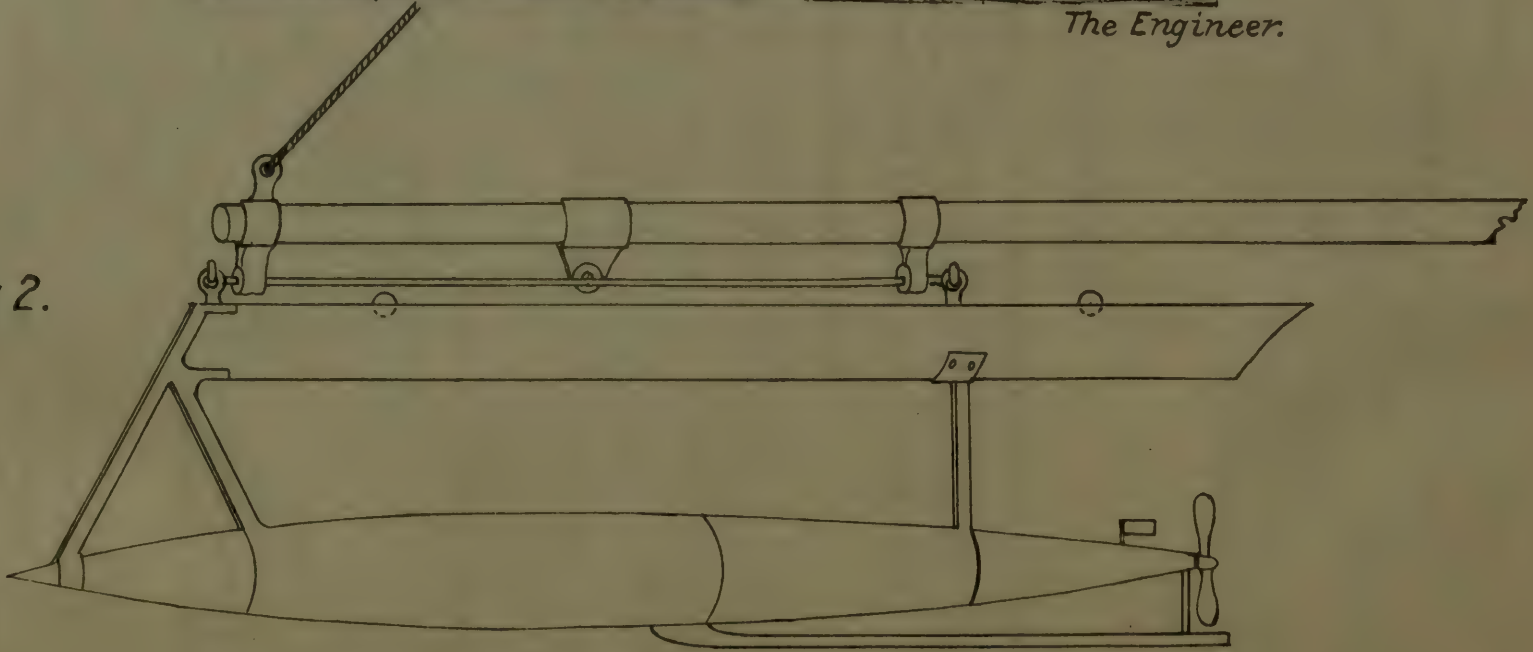
In order to increase the efficiency of this torpedo, so that it can be manipulated from a vessel underway, as well as from a fixed station on shore, experiments have been conducted in England, during the past year, with a launching apparatus devised at the works of Armstrong & Co. For this purpose the torpedo was suspended by two ringbolts in its float, which were hooked over lugs of a tumbler-rod locked by a trigger; when the trigger latch is released the weight of the torpedo causes the tumbler to turn and drop it.

Fig 1.



The Engineer.

Fig 2.



Launching Gear (Sims-Edison Torpedo)

On board the *Drudge* (Plate XIV) the tumbler frame was fitted on rollers on an overhead track, and the detaching was accomplished automatically when the torpedo was clear of the ship's side, it entering the water with an initial impetus which assisted it to clear the vessel. It is proposed, for service spar-deck use, that this tumbler frame be swung out by a boom, and that the torpedo be released, in its normal position, by a tripping line; or, when used between decks, that the torpedo be run out through a port, in a horizontal position, on two telescopic guides, and that either the clip supporting the body of the torpedo be tripped first to let it swing to its normal position before dropping, or both be tripped simultaneously, the torpedo righting itself after entering the water.

During four preliminary private trials, during which the *Drudge* ran at slow speed, the launching apparatus worked well, one accident occurring February 12 by the cable fouling the screw. This was provided against by lengthening the guide tube. The cable was payed out from the vessel, as well as from the torpedo, and the propeller was started before entering the water. The torpedo was always under perfect control, excepting on February 12, when the steering gear became unmanageable, due to the improper setting up of the terminal binding screw. The speeds attained were not great; 15 knots on January 12, said to have been reached with a reduced current, and 13 knots, February 3, with a defective dynamo.

On February 5, 1892, the final trial took place in Stokes Bay, near Portsmouth, in the presence of a number of foreign officials. While the *Drudge* was running at a speed of 4 knots the torpedo was launched successfully, manœuvred accurately, and ran out its 7,000 feet of cable in 4 minutes 10 seconds, or at the rate of 18.1 knots an hour.

The objections to this system seem to be:—The slowness with which the torpedo starts and clears the ship; the liability of the cable to foul its own propeller or that of the ship from which it is operated; and, as yet, its lack of speed.

WHITEHEAD.

During the English manœuvres of 1891, of eight Whitehead torpedoes discharged at vessels it is reported that three failed to run on account of the failure of the water trippers to act, two of which are now fitted; four missed the mark; and that the only effective one was discharged after the boat was declared out of action. Again, that during practice in deep water in August ten torpedoes were lost, and that of three that went adrift in Suda Bay in October only one was recovered.

In spite of these erratic results the Whitehead torpedo still continues to be the chief one in service abroad, and several countries have established factories of their own and are taking such steps in their manufacture as will make them independent of the Fiume Works. The experience of France during the past year, would indicate that such a move on her part is absolutely necessary to supply her present demands.

The Whitehead Works at Fiume have lately supplied Chile, England, and Italy with the new 18-inch torpedo, length 16.4 feet, weight 1,100 pounds, charge 220 pounds gun cotton, and speed 32 knots for 437 yards; and Austria, Denmark, and France with the smaller types. France and Austria have lately ordered 18-inch torpedoes, to have a speed of 29½ knots for 875 yards, and to carry a charge of 198 pounds of explosive.

The new torpedoes embody several improvements over the model 1885; one is in the valve regulating the speed of the propellers before and after immersion (page 389, No. IX), which now functions satisfactorily; another is in the insertion of a positive screw valve between the air and machinery compartments, to confine the air absolutely until a short time before firing. This occasions another adjustment before firing, but, with it closed, a reservoir can be left charged for months.

The power of the large torpedoes, with their length and weight, is now such that they are not deflected, even in a heavy sea. The highest speed stated to have been yet attained for a short distance is 34 knots.

The blunt-headed torpedoes are fitted with a spider-shaped attachment, either of the arms of which act on the firing mechanism at a glancing blow.

The Whitehead Company is erecting a factory in England, near Portland, which they expect to occupy this summer, removing most of their business from Fiume to it for economy's sake.

ENGLAND.

Whitehead.—The locating of Whitehead's principal factory in England, in addition to the torpedo works of Greenwood & Bartley, and those at the Royal Arsenal at Woolwich, will furnish England with very fertile resources from which to draw her supply.

It is stated that Greenwood & Bartley are furnishing excellent work for the Government, and that the Woolwich Arsenal has a capacity of 400 torpedoes per annum. During the year ending December 31, 1891, 126 Whitehead torpedoes were added to those in service.

The latest Woolwich pattern 18-inch torpedo has a very bluff head, and is designed especially for use with under-water discharge. It carries a charge of 250 pounds of gun-cotton, has passed through successful trials, attaining a speed of 30 knots for 700 yards, and has been accepted by the Government. The 18-inch torpedoes are to be fitted to the larger class of vessels, and the 14-inch to the smaller ones.

Brennan.—The last payment was made by the Government on the Brennan dirigible torpedo in September, 1891, and it is now their property.

During the Thames River defense operations, September 22, 1891, this torpedo operated well, and at a distance of 1,000 yards was made to turn almost in its own length. On June 8, 1892, two torpedoes failed during operations off Portsmouth; one, by the slipping of a band, and the other by suddenly diving after running only 400 yards.

The total number of torpedoes afloat and in reserve December 31, 1891, in the English naval service was 2,874.

FRANCE.

On account of delays at the Whitehead Works at Fiume in filling French orders, there remained unexpended $290,000 of the yearly appropriation for torpedoes. France has now commenced to manufacture them at the Government factory at Toulon, by the aid of which it is expected to supply all demands at reduced cost.

A recent order from Whitehead's Works at Fiume includes several torpedoes of the 18-inch type; charge, 198 pounds; speed, 29.5 knots for 875 yards.

SPAIN.

Action has been taken by Spain looking toward making her independent of foreign countries for her torpedo supply.

A fish torpedo, probably of the Schwartzkopff type, carrying a guncotton charge of 88 pounds, has lately been constructed at the Cartagena arsenal, and has made successful trial runs.

UNITED STATES.

Whitehead.—E. W. Bliss & Co., of Brooklyn, N. Y., have acquired the patent rights of the Whitehead torpedo, and are now constructing, under contract with the Navy Department, one hundred 18-inch torpedoes, which are to carry 120 ~~250~~-pound gun-cotton charges.

Howell.—Successful trial runs were made with this torpedo at Newport, R. I., last December, and a number of them have now been ordered for service.

The trials were made from a stationery deck gun, 7 feet above water, range 400 yards. The average speed of nine runs was 22½ knots, and the deviations, average of ten runs, were, vertical, 2.764 feet, horizontal, 21 feet.

ERICSSON SUBMARINE GUN.

The gun and projectile as fitted on board the *Destroyer* are shown in Plate XV, ready for firing.

The gun is fitted with a slotted-screw breech mechanism. The diameter of the bore is 16 inches, and the chamber is enlarged, there being a decided shoulder at *a*. The bow shutter G is controlled by a rod actuated by the compressed air cylinder and piston C. The drain-pipe *n* is controlled by a valve; I, is the compressed air cylinder connected to the gun chamber by the valve and pipe *l*, and *y* is a set-screw stop.

The projectile is made in three sections, for convenience in handling and stowing, which are connected up before loading. It is fitted near the head with a leather grommet, *p*, and has horizontal and vertical tail fins.

The piston head *f* has a hollow stem screwed into it, which is slightly longer than the propelling charge, and is provided with spring packing rings which cause it to fit neatly during its passage through the bore or the chamber. It has a centre recess in its front face, in which seats the tail end of the projectile, to which it is secured by a set screw. On its rear face is a soft metal annular ring of such diameter that it admits of passage through the enlarged chamber, but is greater than the diameter of the bore.

The working of the gun is as follows: The bow shutter G being closed, and the water drained out of the gun through *n*, the breech is opened and the projectile, on a carriage in line with the gun, is run into the bore until the tail just projects to the rear. A piston head is then fitted to its tail, and the set screw is tightened sufficiently to keep it from turning, but loose enough to allow it to slide off when it meets the resistance of the water. The projectile is then shoved farther home, until its base is in the position shown by the dotted lines in the figure, at which time the washer *p* will fit the bore snugly. The powder charge, centred in the bore on the legs of its case, is then inserted the electric primer fitted, and the breech closed.

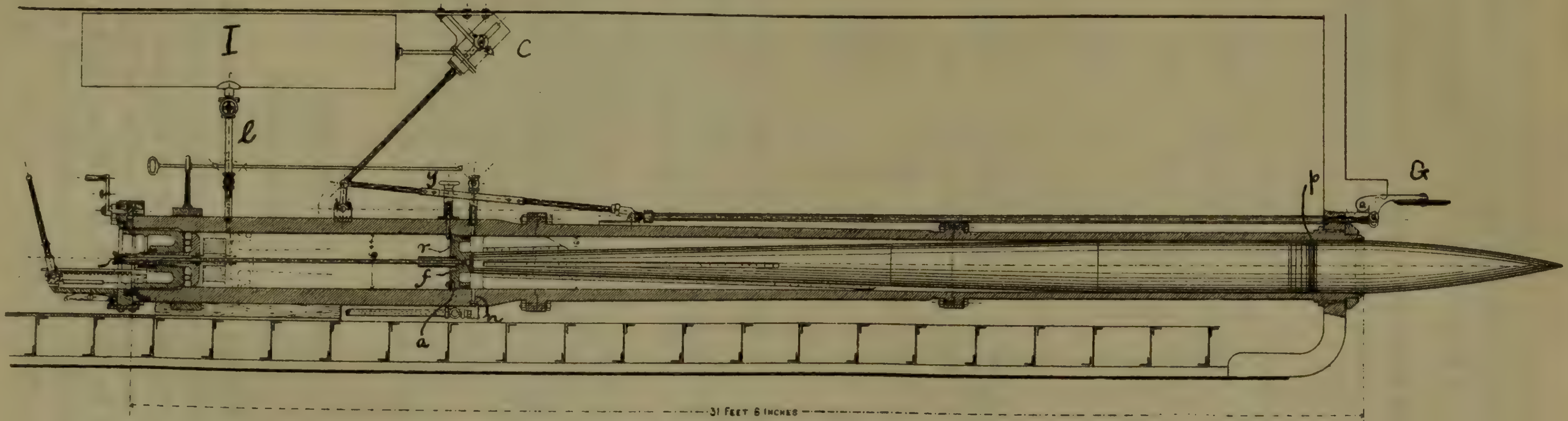
The shutter G is opened; then the valve *l*, admitting compressed air in rear of the piston *f* and forcing it and the projectile forward in the bore, to the position shown in the figure. The forward movement is stopped, in this position, by the annular ring on the rear face of the piston taking against the shoulder *a*. The stop-screw *y* is then screwed down as a safeguard to prevent the projectile from being forced in by the water pressure, should it from any cause exceed that of the air pressure.

The valves *n* and *l* are then closed and the gun fired. The pressure of the powder gas causes the annular base ring of the piston to curl back when forced against the shoulder *a*, and thus cupped it allows of forward movement, at the same time acting as an additional gas-check. Upon entering the water the piston head falls off, free from the projectile. The shutter G is then closed, the drain cock *n* opened, and, when freed of water, the gun is ready for another charge.

Experimental firings have lately been conducted by the Torpedo Board with the gun fitted to the *Destroyer*.

The boat was moored 100 feet from the dry dock, in which were suspended six nets, 40 feet long by 20 feet deep, each 100 feet apart, their centres being in the centre line of the dock. Firing thus into the dock insured the recovery of the projectiles to facilitate investigations as to the causes of possible erratic shots.

ERICSSON SUBMARINE GUN.



Submarine Gun for the Destroyer.

Weight of Projectile,	1,525 pounds.	Initial Pressure,	4,000 pounds.
Length ,, . .	27 feet, 4 inches.	Mean ,, . .	1,692 ,,
Diameter ,, . .	16 ,,	Muzzle ,,	895 ,,
Explosive Charge, . .	300 pounds	Work in Foot-Pounds,	7,927,544 ,,
Propelling ,, .	40 ,,	Muzzle Velocity, . .	548 feet.

Journal of Iron & Steel Institute.

Twenty shots have thus far been fired, one of which was with a special automatic projectile. The firing charges employed have not exceeded 30 pounds, although the gun is designed to withstand 40-pound charges.

A good idea of the capabilities of the gun and projectile can be had from the following data of three of the best shots:

Net at a distance of—					
100 feet, hit at—		200 feet, hit at—		300 feet, hit at—	
Depth.	Lateral.	Depth.	Lateral.	Depth.	Lateral.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
6	0	6½	½ left	7	3½ right
8	0	8	2 left	6	4 left
8	1 left	9	4 left	6	8 left

Net at a distance of—					
400 feet, hit at—		500 feet, hit at—		600 feet, hit at—	
Depth.	Lateral.	Depth.	Lateral.	Depth.	Lateral.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	8 right	3½	16 right	(?)	(?)
1	9 left	8	14 left	(?)	18 left.
2	14 left	(?)	(?)	(?)	(?)

It must be remembered that failure to hit the centre of other than the first net does not necessarily apply to inaccuracy of run of projectile, but may be accounted for by the boat sagging out of position at the instant of firing. The straightness of track of the projectile is the indicator as to its accuracy.

From the results thus far attained it is safe to say that the experiments have demonstrated the possibility of firing a submarine projectile 600 feet by powder discharge; that up to that range the vertical danger space is from the surface to a depth of 22 feet, and the lateral accuracy sufficient to strike a vessel 50 feet long.

The effect of the explosion of such a charge of high explosive, even at the water line of a vessel, if not proving fatal, would certainly do great damage.

TORPEDO DEFENSE.

TORPEDO-BOOM EXPERIMENT.

The following experiment took place at Haslar Creek, near Portsmouth, England, October 22, 1891, to test the efficiency of a torpedo-boat boom defense, designed by the Admiralty, for narrow channels:

The boom consisted of six wooden balks, 1 foot square and from 30 to 40 feet long, arranged parallel to each other at intervals of 8 feet, and end on to the line of attack. Each was armed with an iron-pointed head and four iron horns, inclined forward, two on the end and two in the middle. They were bound together by three 7-inch steel hawsers on their under side and two 5-inch steel hawsers on their upper side. In addition to these, another hawser, 6 inches in diameter, was secured in place 6 feet above the balks by vertical iron stanchions fitted to the middle of each. This sixth hawser was to prevent the boat from jumping the obstruction. The whole system was stretched across the mouth of the creek, the ends being secured on barges moored on either side.

Torpedo boat No. 76 was fitted for the attack with two hog-frames extending over all and inclined down to the deck at the stem and stern, joining in one from over the forecastle to the stem. The height of these frames was that of the hinge of the smoke-stack, which was lowered just before the attack. The boat was trimmed by the stern and her bottom was unprotected.

The boat, steaming at full speed, struck the centre of the obstruction, riding up on the first hawsers, but being finally brought to a standstill by the overhead hawser, which caught on the anchor gear and jammed the boat down on the spiked balks. In this position she might have discharged her bow torpedoes.

She backed herself clear, but sank before reaching the shore, Lieut. Sturdee and the crew being taken off by other boats. Upon being raised and docked her injuries were found to consist of a large hole in the port bow, and another one torn in the skin below the engine compartment.

NET-CUTTING ATTACHMENTS.

Wilson.—On October 1, 1891, a net-cutting device, designed by Capt. A. K. Wilson, R. N., consisting of a scissor attachment for Whitehead torpedoes, was tested at Portsmouth.

Although when fired normally it succeeded in effecting a passage through the net, still it would seem as if the strength of the latter could be materially increased if required, and sufficiently so to resist the attacks of such a device.

That the Admiralty does not place much reliance on the cutter is shown by their recent order that all armored cruisers in course of construction shall be fitted with Bullivant nets.

Bellamo.—Another net-cutting device, believed to be a scissor-like attachment at the head of a torpedo, is the Bellamo. It has been experimented with in Italy, and as a result has been adopted for use with either the Whitehead or Schwartzkopff fish torpedoes. Germany has also purchased the right to use it, and France employs another system known as the Niccolini la Hitt, the action of which is not known.

TORPEDO-DISCHARGING APPARATUS.

The Whitehead underwater launching apparatus (page 136, No. IX) has not been found to be a success in Italy and Germany; and it is a noticeable fact that the three armored vessels asked for by the Austrian

Minister of Marine are not designed to be fitted with torpedo-launching apparatus.

The English are having better success with their underwater tubes, designed by Capt. Wilson, R. N. During experiments on board the *Vulcan*, excellent runs, without deflection, are said to have been made with a broadside 18-inch torpedo, speed of ship 18 knots, and of torpedo 26 knots, during which the maximum water pressure on the shield was stated to have been 5 tons per square inch. Later experiments with an improved tube, fitted to the *Blenheim*, also proved successful, using a 14-inch torpedo, vessel steaming 18.5 knots.

As fitted to the *Royal Sovereign*, the submerged tubes are 12 feet below the water line, and are stationary, thus dispensing with the ball and socket joint at the ship's side. The shield is run out by hydraulic power.

The short 18-inch Whitehead torpedo is not well adapted to underwater discharge.

For over-water discharge, powder impulse seems to be growing in favor over that of air.

SMOKELESS POWDER.

AUSTRIA (Model 1890).

The smokeless powder (model 1890), adopted by Austria, is the Schwab-Rubin, which is a modified form of the Schwab. (Page 120, No. IX.) It is manufactured at the Government factory at Blüman, near Vienna, is said to produce a light blue smoke, and to be rapid in its combustion, producing high pressures in the piece. The Army Budget for 1892 contains an estimate of $900,000 for its manufacture.

In the following comparison of the Schwab-Rubin with black powder it is regretted that the pressures in the bore are not known:

Type of small arm.	Calibre.	Kind of powder.	Weight of charge.	Weight of bullet.	Initial velocity.
	Inches.		*Grains.*	*Grains.*	*f. s.*
Mannlicher, M/88	.315	M/90	42.4	243	2034
Do	.315	Black	61.7	243	1738

DENMARK.

A new smokeless powder has been produced at the Danish Government factory, which is reported to make very little smoke and not to overstrain or badly foul the piece. Three thousand rounds have been fired from one piece without damaging it, and twenty-four hours after firing a piece no difficulty was experienced in cleaning it.

The following results were obtained using this powder in an 8^{mm} Krag-Jörgensen small-arm:

Bullet	grains	237.6
Charge	grains	33.95

Chamber pressure per square inch	tons	16.4
Danger space, no elevation	yards	563
Initial velocity	f. s.	1,968
Range	yards	3,827

In September, 1891, comparative volley-firing tests were made of the old and new powders, employing two companies of 100 men each, armed with the 8^{mm} Krag-Jörgensen rifle. The following results were recorded:

Distance.	Per cent of hits.	
	Old.	New.
Yards.		
1,476	0	1
930	10	26
437	20	37

ENGLAND (Cordite).

The composition of cordite is described as follows, in the application of Sir F. A. Abel and J. Dewar, dated April 2, 1889, for a patent relating to the manufacture of explosives for ammunition from blasting-gelatin or its compounds:

> This material, made in the usual way, but with a greater percentage of nitrocellulose and with sufficient solvent, such as acetone or acetic ether, to produce a moderately thick jelly, or ordinary blasting gelatin, to which soluble nitrocellulose and solvent have been added, is pressed through holes of various sizes so as to form a number of wires. When the latter have become toughened by evaporation of the solvent, they are cut into lengths, which are packed side by side in the shells or cartridge cases. The rapidity of combustion increases as the diameter of the wires is diminished.

As yet this powder is still in the experimental stage. It has been reported to produce deteriorating effects on the bores of guns; and that after having fired one hundred rounds without accident, in a new magazine rifle, a slight change in the size of the pellets caused the rifle to burst. It was also stated to have exuded liquid nitro-glycerine when stored in bulk; and to become dangerous when kept at a temperature of 100° F., its explosive force increasing largely; and that when subjected to the winter climate of Halifax, a slight liquifying of glycerine took place, although this is considered by some as not affecting its serviceability. When frozen it is said to become quite inert. Exposure to the sun is not supposed to affect it.

For a nation having such widely separated colonies as England the climatic properties of a powder are of vital importance; therefore, during the past year, samples of cordite have been stored in Canada and India for test purposes.

These tests have shown that, as now manufactured, cordite does not deteriorate under the influence of extreme cold, and, although the heat tests in India are not yet concluded, the results are so promising regarding its climatic stability, that its manufacture at Waltham Abbey is now proceeding on an extended scale.

A large number of small-arm cartridges filled with cordite have been manufactured, and will be issued to the troops during the coming season for firing tests, orders having been issued by the War Office, last February, to replace the new magazine rifles in service by others sighted for cordite ammunition.

Experiments to determine its erosive and other effects on rapid-firing guns are progressing, and are to be conducted later on with guns of larger calibre.

During the army manœuvres of 1891 a charge of 1 pound 1 ounce of cordite was found to give the same initial velocity (1,710 f. s.) as 4 pounds of black powder when used in the new 6-pounder, 12 cwt., wire-wound field gun.

An initial velocity of 2,657 f. s. has recently been obtained with cordite in a 6-inch Armstrong R. F. gun.

FRANCE (BN).

The French BN smokeless powder seems to stand all service tests satisfactorily, and to give good ballistical results.

The *London Times* correspondent states that during the army manœuvres of 1891 it proved to be almost smokeless. At 2,000 yards a faint cloud is seen, which disappears so quickly that it would not reveal the position of the guns, nor assist an opposing battery to lay its guns. The flash, however, is very distinct and is plainly visible at 5,000 yards.

GERMANY (C/89).

The Nobel, C/89, smokeless powder has not produced altogether satisfactory results in Germany, especially when used in small-arms. In them it develops a pressure of 21 tons per square inch, which they are hardly able to withstand, and produces excessive heating of the barrel, estimated at 6° per round. With regard to the quality of smokelessness, it is very good, giving off a light-brown puff which can hardly be distinguished.

A process of coating the grains with graphite to prevent them from caking, exuding, or absorbing moisture during storage, has lately been tested by Krupp and given good results. The average variation in weight for one year was found to be 0.08 per cent, while black powder varied from 0.14 to 0.24 per cent. Improvements have also been made in the heat qualities of the powder, a lot which had been subjected to a temperature of 50° C for 15 days, giving an increased velocity of 68.9 f. s. and chamber pressure of 1.57 tons per square inch, in an 8.7^{cm} gun, over another lot which had been kept at a normal temperature.

That successful improvements have been made with this powder would seem to be indicated by the large appropriation asked for in the Budget of 1892.

ITALY. (Balistite.)

Although it has been stated that balistite develops great heat, causing erosion of the bore, and that its pressures are very high, the Italians seem to be satisfied with it in service.

During the autumn of 1891 balistite charges were used in field guns, and are stated to have given good results, not affecting the guns badly and bringing reduced strains on the mount.

During trials for rapidity of fire with the new magazine rifle, balistite charges so heated the barrels that in some cases the lead of the bullets was fuzed in their envelopes upon the introduction of the cartridges into the piece.

RUSSIA.

Although its composition is not known, still it is believed that Russia is actively engaged in the production of a smokeless powder. Three Government ammunition and powder factories are reported to be working full force, and a fourth factory has lately been erected and will soon be in operation.

A recent report in *Iron* states that the Government has placed an order for 12,857 tons of smokeless powder at the works of the Schlüsselburg Powder Company, near St. Petersburg.

SPAIN.

Spain is also interested in producing a smokeless powder. It will be produced first from the works at Bilboa, and afterwards from those at Grenada.

SWEDEN. (Apyrite.)

Apyrite, a modified form of Grakrut (page 119, No. IX, and page 174, No. X) which it supersedes, is the new Swedish smokeless powder. It is composed of two substances, the principal one being highly nitrated cellulose, and is made by the Grakrut Society. The grains are triangular prismatic in shape, base .041 inch, height .035 inch, and are lustrous black in color.

It is less sensitive to bullet impact than black powder, does not explode when ignited in large quantities, and does not deteriorate when kept in store in warm climates. It is sensitive to hygroscopic changes, absorbing moisture readily, but giving it off without deteriorating at a temperature of 30° C.; but when hermetically sealed, as in cartridges, it remains unchanged. It produces less smoke than Nobel powder, C/89, gives off little flame, and has less heating effect on the barrel than black powder, twenty-three rounds with it producing the same elevation of temperature as ten rounds of black powder. The principal defect of this powder is that it fouls the bore and mechanism, making cleaning very difficult, but this objection is said to have been obviated in the later manufacture.

Trials at Rosersberg, December, 1890, and January, 1891, with the new Swedish rifle, Remington-transformed, M/67–89, gave the following results:

Calibre.	Charge.	Bullet.	Initial velocity.	Pressure. per square inch.
	Grains.	*Grains.*	*f. s.*	*Tons.*
8mm.	53.23	223.7	2,044	15.88
8mm.	53.23	239.0	2,021	17.59

Although it was desired, in producing the powder, to obtain velocities of from 2,067 f. s. to 2,132 f. s. with pressures of from 14.43 to 16.66 tons per square inch, cartridges loaded with apyrite and steel enveloped bullets were made and issued, in the spring of 1891, to the Foot Guards armed with the transformed rifle. The results seem to have been poor, for during experimental firings, during which about 35,000 rounds were expended, numerous accidents to the breech mechanism occurred.

The authorities gave orders to stop the firings, and stated that the reason for the accidents was that the gun was not designed for the increased pressures produced by the smokeless powders of the day. They are now taking steps to so modify the composition of the powder as to limit the pressure to 15.09 tons per square inch, as that is the limit of strength of the Remington-transformed rifle, M/67–89.

When used as charges in rapid-fire guns, apyrite has given the following results:

Calibre.	Type of gun.	Charge.	Projectile.	Initial velocity.	Pressure per square inch.
		Pounds.	*Pounds.*	*f. s.*	*Tons.*
8cm	M/81......	1.61	15.00	1,542	9.94
57mm.....	Finspong.	1.18	6.00	2,198	14.76

The black powder charge to produce similar results in the 8cm R. F. gun is 3.3 pounds. Using apyrite, a priming charge of 46.3 grains was employed in this gun.

It is now stated that when used in the Government small-arm, charges of 54 grains of apyrite produce an initial velocity of 2,099 f. s. with a chamber pressure of 14.83 tons.

SWITZERLAND (P. C./89).

A smokeless powder, known as P. C./89 (Powder composition, 1889), manufactured at the Government factory of Worblaufen, has been in use for two years with the Schmidt magazine small-arm.

After a series of experiments, conducted during the past year, smokeless powder has also been adopted for artillery purposes.

For economy's sake, part of the demand will be met by foreign purchase, and the remainder will be supplied by the Government factory.

This powder, P. C./89, is manufactured in the form of square wafers of light-brown color, and produces very little smoke and slight fouling. Its ingredients are not known.

UNITED STATES.

A smokeless powder has been produced at the U. S. Naval Torpedo Station which has withstood severe heat, water, and detonating tests, and which is expected to show good keeping qualities. The following are some of the results obtained with different samples of this powder:

Calibre.	Charge.	Projectile.	Pressure.	Initial velocity.
			Tons.	*f. s.*
.301 inch	42 grains	215 grains	12.0	*2,100
47 mm	....	3.3 pounds	14.8	2,250
57 mm	....	6 pounds	14.3	1,920
4-inch R. F	5¼ pounds	33 pounds	14.0	2,100
5-inch R. F	10¾ pounds	50 pounds	15.2	2.540
6-inch	21 pounds	100 pounds	14.4	2,300

* At 60 feet from muzzle.

The U. S. War Department is conducting experiments at the Frankford Arsenal with a view of producing a smokeless powder.

HIGH EXPLOSIVES.

JUSTIN AND SNYDER SHELLS.

The most important experiments undertaken during the past year by private parties to develop the use of high explosive projectiles in powder-charged guns, have been those of Justin in the United States, and Snyder in South Wales.

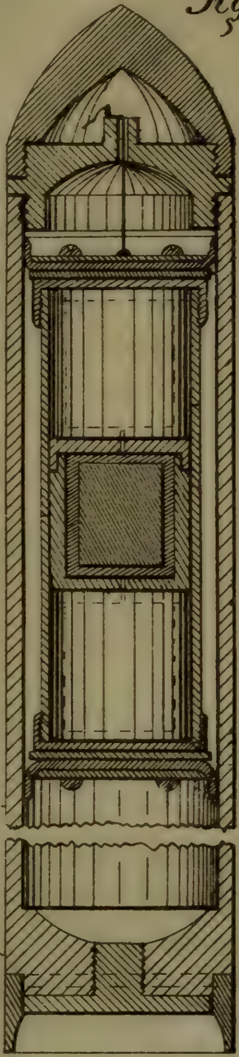
Justin.—To relieve the shock of discharge (see Plate XVI), Justin places his explosive, surrounded by a compressible absorbent, in wooden boxes which are contained in a cylindrical carrier. This carrier is of less diameter and shorter than the body of the shell, and is fitted with leather discs having overturned edges, which are secured on the top and bottom of the carrier by washer heads and rubber relief-discs. A wire holding the carrier in a forward position is broken upon shock of discharge; the body of the shell moving forward, the inertia of the carrier forces it to the rear, compressing the air behind it. This compressed air forces its way in front of the carrier by passing through ports in the rear leather discs, so that the cushioning effect of the compressed air is regulated by the sizes of these ports. The shell is exploded on impact by either a percussion or delayed-action fuze.

Dr. Justin ascribes the causes of the failures of previous experiments to weakness of the base of his projectiles.

At Perryville, N. Y., September 1 and 10, 1891, shells were successfully fired from a 5-inch Parrott rifle and an 8-inch Blakely. On Decem-

JUSTIN HIGH-EXPLOSIVE SHELL

Fig. I



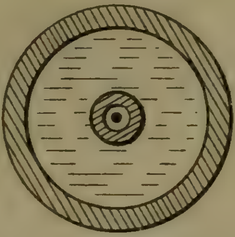


Fig. 2.

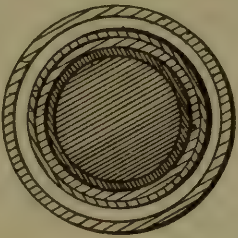


Fig. 3

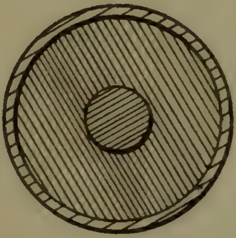


Fig. 4.

SNYDER HIGH-EXPLOSIVE SHELL

Fig. 1.

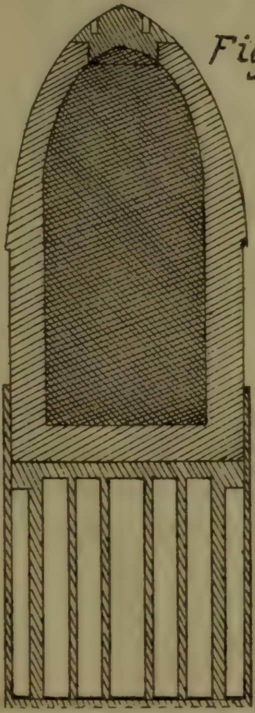
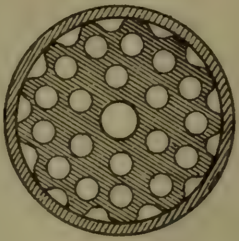


Fig. 2.



ber 22, 1891, a shell containing 30 pounds explosive-gelatin was fired with a charge of 30 pounds brown prismatic powder from a 6-inch Parrott rifle at a bank of earth 25 yards distant; it penetrated 17 feet without exploding. Another unfuzed shell, charged with 8½ pounds explosive-gelatin, failed to explode on impact when fired at rock 230 yards distant.

A modified form of shell in which the rear face of the carrier is convex, so as to diminish the rear surface area which tends to rotate the charge with the body of the shell, due to the rifling, and thus decrease friction, was tested, June 20, 1892, with the following results:

Gun.	Number of shots.	Projectile.	Charge (explosive gelatin).	Remarks.
		Pounds.	*Pounds.*	
5¼-inch Parrott	5	56¼	6¼	Four against a stone precipice. One through ⅝-inch steel and 16 feet of earth, without exploding.
Do..............	1	60¼	5	Through ⅝-inch steel and exploded in butt by delayed-action fuze.
9-inch Blakely.........	3	225	34	Successfully discharged.
Do...............	3	214	36½	
Do..............	1	254 a. p.	30	Perforated 3 inches steel and exploded in backing by delayed-action fuze.

A member of the company is quoted as stating that since June, 1891, one hundred 6-inch projectiles, 3 feet long, containing bursting charges of 30 pounds, have been fired without accidents.

Snyder.—The method employed by Snyder to relieve the shock of discharge is also shown on Plate XVI.

The projectile has the usual ogival head, a solid base, and the rear half of its cylinder is turned down to a less diameter than the calibre of the gun. Fitted over its base is a brass cylinder, with solid base and open head, containing a fluted rubber cylinder, which is pierced with about thirty holes. When the discharge occurs, the pressure of the powder gases shortens the cylinder, compresses the rubber and contained air which produce the cushioning effect, and bulges the cylinder so that it expands and takes the rifling of the bore of the piece. The base cylinder drops off soon after leaving the muzzle. These projectiles can be used with either rifled or smooth-bore guns.

Experiments were conducted with this system of projectiles at Aberdare, South Wales, October 5, 1891.

Using a 7-inch Blakely M. L. R. and a 6-inch Armstrong B. L. R., projectiles weighing 229 pounds and 218 pounds, respectively, containing 10 pounds of explosive-gelatin of 4 per cent camphor, several rounds were fired with low velocities at 3 and 6-inch wrought-iron targets. No accidents or premature explosions occurred, but the effects on the targets were not very marked, due, probably, to insufficient delayed action on impact, or to low velocities.

On October 20, 1891, a 7-inch shell containing a bursting charge of 12½ pounds of explosive-gelatin was fired through a ½-inch steel plate and buried itself in a hill 400 yards distant without exploding. Another shell, containing an explosive charge of 7½ pounds of dry guncotton and three-fourth pounds of explosive-gelatin, was also successfully fired with the usual powder charge.

It being considered doubtful whether these projectiles would safely withstand the pressures developed with high velocities, two rounds were fired February 1, 1892, during which all details were conducted in the presence of two retired English army officers. The object of this trial was to give conclusive proof of the safety with which explosive-gelatin could be fired in these shells from powder guns.

Details of trial:

	Round 1.*	Round 2.†
Gun, Armstrong B. L. R.	6-inch	6-inch
Projectiles:		
Weight, empty .... pounds	70	68
Nitro-gelatine charge .... do	7	7
Loaded shell .... do	78	76
Rubber buffer and case .... do	21	21
Total weight .... do	99	97
Charge:		
Black prismatic .... do	....	45½
Brown prismatic .... do	50½	....
Initial velocity .... f. s.	1, 284	1, 766

* The low velocity of round 1 is attributed to the damp powder used.

† The projectile used in round 2 had two ring grooves cut in its head to bite when striking at an angle.

Both projectiles exploded on impact with a soft bank. Portions of the brass cases, showing rifling impressions, were found scattered along the line of flight.

ENGLAND (Lyddite).

The English continue to experiment with Lyddite as a bursting charge for shells, with varied results.

A French paper mentions a trial in which a steel plate resisted penetration, and other accounts record the bursting of a mortar at Lydd, during experimental firing last November, presumably with Lyddite-charged shells.

As yet developed, Lyddite-charged shells are not considered safe enough to place on board ship, no vessels being yet supplied with them.

FRANCE (Melinite).

La Marine Française gives a description of recent experiments which have taken place in France, by a Commission presided over by M. Eynaud, to determine the effect of melinite shells against (1) protective decks and (2) light-armored upper works. The following extracts are taken as being of interest:

(1) *Firing against protective decks.*—The target consisted of a plate 3.54 inches thick, backed by 0.394 inch sheet iron, bolted to double T (⌶) beams. A plate 0.394 inch thick, placed square with the protective deck and 21.65 inches in front of its armor, represented the ship's side. A splinter screen 0.315 inch thick was placed 3.28 feet behind the protective deck.

The projectiles used were 32^{cm} (12.6-inch) common cast-iron fuzed shell, 33.47 inches long, weighing 645 pounds, carrying a charge of 55 pounds melinite, fired with striking velocities ranging from 1,594 f. s. to 1,673 f. s.

The results of the trials showed that 0.315-inch sheet iron caused melinite projectiles to explode, either during penetration or just after perforation, and before striking the protective deck, which was simply affected by the blast of explosion. When the explosion occurred during penetration, a hole about 6½ feet square was blown in the ship's side, and the injury to the deck depended upon its distance from the point of explosion.

When the projectile perforated it always burst within 5¼ feet of the back of the plate, and failed to rupture the protective deck unless the explosion occurred within 3¼ feet of it. When such rupture occurred to the deck it was limited to a surface area of 3¼ feet square, and a splinter screen, 0.315 inch thick, placed 3¼ feet behind it, was found to be insufficient protection against flying fragments, some of which weighed as much as 440 pounds.

The Commission concluded that an additional thickness of 0.591-inch sheet iron to the vessel's side, between the protective and gun decks, would be sufficient to cause the shells to burst before approaching the danger limit of the protective deck.

(2) *Firing against light-armored upper works.*—The target, representing the light upper works of the *Brennus*, was an iron plate, 4.72 inches thick (representing 3.94 inches steel), 3¼ feet high, backed by two thicknesses of 0.394-inch sheet iron. Above it was a plate 0.315 inch thick, and its bottom rested on a protective deck at right angles to it, varying in thickness from 3.15 inches to 1.58 inches, backed by two 0.394-inch iron plates.

It was attacked by a 32^{cm} (12.6-inch) gun with similar projectiles to those in the preceding experiment, loaded with melinite and black powder, and by a 16^{cm} (6.3-inch) gun firing common cast-iron shells charged with 8.8 pounds melinite and with black powder.

The Commission state as the result of the trials, basing their opinion on the showing of the 6.3-inch projectiles, that 3.94-inch steel armor, backed by two 0.394-inch iron plates, is sufficient protection against 7.48-inch cast-iron shells with a striking velocity of 1,968 f. s. when charged with melinite.

When, however, the armor is attacked by powder-charged shells, which perforate before explosion, or by large melinite-charged cast-iron shells striking normally with velocities of 1,968 f. s. to 2,132 f. s., or greater, the armor is worsted. In the first case, the armor and upper works are simply perforated; but in the latter case, that of large melinite shells, a surface of 3¼ feet square of the armor is demolished, fragments weighing 440 pounds being thrown 656 feet, and the upper works are ruptured by holes 13.12 feet square. The horizontal effects extend from 8.2 feet to 9.84 feet. A protective deck, 1.97 inches thick, is efficient protection in these cases, if it is backed by a splinter screen to stop flying bolts and nuts.

As the height of the armor belt is 3.98 feet, and experiment No. 1 showed that 3¼ feet is a safe distance for explosion to occur from the protective deck, the Commission conclude that in a ship constructed like the target, the protective deck is safe from the attack of melinite shells which perforate the light works above the armor.

In February, 1892, at Lorient, a 32^{cm} shell burst prematurely, killing the man handling it. The explosion occurred during the withdrawal of the fuze-chamber-shaping mandrel after the melinite had cooled and solidified.

On April 5, 1892, in the presence of the Minister of War, at the firing grounds of Renardières, 10 melinite-charged shells were successfully fired from a mortar, demolishing a target at a range of 1,970 yards.

GERMANY.

According to foreign prints, the Germans have acquired a new high explosive, to be used as bursting charges for shells in the navy as well as the army, which is said to combine incendiary effects with great explosive force.

It is said that against targets on shore its effectiveness was remarkable, and that an old ironclad at Kiel was sunk after four rounds had been fired at her.

ARMOR FACE-HARDENING TREATMENTS.

The two armor face-hardening treatments which have been most prominent during the past year are the Harvey and the Tresidder processes. The former has been used in the United States and the latter in England for treating special plates. The action of these plates under attack is dealt with in Chapter VII, but it is deemed more desirable to describe the different treatments under the "Notes on Ordnance."

THE HARVEY PROCESS.

The process Mr. H. A. Harvey employs for face-hardening armor plates is thus described in his United States patent specification (see Plate XVII):

> The armor plate having been formed of the desired size and shape from a comparatively low steel, such as Bessemer steel or open-hearth steel, containing say 0.10

per cent to 0.35 per cent of carbon, is laid, preferably flatwise, upon a bed of finely powdered dry clay or sand, deposited upon the bottom of a fire-brick cell or compartment erected within the heating chamber of a suitable furnace. The plate may be so embedded that its upper surface is in the same plane with the upper surface of those portions of the bed of clay or sand which adjoin the sides and ends of the plate, or the plate may, if desired, be allowed to project to a greater or less distance above the surface of the clay or sand. In either case the treating compartment is then partially filled up with granular carbonaceous material, which, having been rammed down upon the plate, is covered with a stratum of sand, upon which there is laid a covering of heavy fire bricks. The furnace is then raised to an intense heat, which is kept up for such a period of time as may be required for the absorption by the metal adjoining the upper surface of the plate of, say, an additional 1 per cent (more or less) of carbon, or, in other words, the quantity of carbon, in addition to that originally present, which may be necessary to enable the said metal to acquire the capacity of hardening to the desired degree. The temperature of the heating chamber outside of the treating compartment is brought up to a height equal to or above that required to melt cast iron, and is kept up for a greater or less length of time, according to the depth of the stratum of steel which it is intended to charge with an excess of carbon. This period, however, will of course vary according to the efficiency of the furnace.

The degrees of efficiency possessed by different furnaces can only be satisfactorily ascertained by actual trial. When ascertained, the reproduction of given results merely requires the reëstablishment of the conditions as to time and temperature under which said results have been previously observed to be obtained. This involves merely the maintenance of the furnace at a heat sufficient to melt cast iron for the period which by previous observation has been ascertained to be the period required for adding to the tenacity of the steel and for the supercarburization of the plate to the prescribed extent and depth. For example, a plate, say, 10½ inches in thickness, composed of a comparatively low steel, containing, say, .35 per cent of carbon, may be charged with additional quantities of carbon, gradually varying in amount from, say .10 per cent at a depth of 3 inches beneath the surface of the exposed side of the plate to 1 per cent at the surface thereof by a continuance of the treatment for a period of, say, one hundred and twenty hours after the furnace has been raised to the required temperature.

The statement that the heat at which the furnace is maintained is sufficient to melt cast iron is to be regarded as approximate merely. The more intense the heat the better, and, while it will of course be understood that the longer the treatment is continued the greater will be the depth to which the carbon penetrates beneath the surface against which the carbonaceous material is packed, it is also to be remarked that the penetration of the carbon is greatly facilitated by the continuous firm compression of the carbonaceous material against the plate. As a general rule, the thicker the armor plate the greater will be the permissible depth of supercarburization. A 10½-inch plate and a depth of supercarburization of 3 inches are herein referred to merely for the purpose of illustration.

After the conclusion of the carburizing treatment the plate is taken out of the furnace and without removal of the carbonaceous material from its surface is allowed to cool down to the proper temperature for chilling. During the cooling operation the carbonaceous material protects the hot supercarburized surface from the air, and thus prevents the formation of scale, which, if present, would interfere with the subsequent hardening of the metal beneath it. The carbonaceous material, however, may without injurious consequences be temporarily removed from and quickly replaced upon small portions of the supercarburized surface for the purpose of exposing them for observation. When it is seen that the supercarburized surface is so far cooled down as to have a dull cherry-red color, the carbonaceous material is quickly removed, and the plate is then chilled by being sprayed with torrents of cold fluid or by being submerged and kept in motion until cold in a large body of cooling fluid—as, for example, a more or less rapidly running stream or river of fresh water or a tidal current of salt water. The exercise of this precaution insures the subsequent uniform hardening of the supercarburized surface of the plate.

The drawing (Plate XVII) represents a furnace A, which may be provided with a movable cover A^1, or which may be constructed with reference to having one or both of its end walls removed to facilitate the removal of the plate in a horizontal direction. Within the heating chamber A^2 of the furnace is the treating cell or compartment B, preferably provided at the bottom with a series *b* of parallel rails, which are embedded in a stratum of sand C of the same height as the rails and are intended for the support of the armor plate D. The space around the ends and sides of the armor plate is also filled with sand C^1 nearly or quite to the top of the plate. A stratum of granular carbonaceous material E, rising to a height of, say, 8 inches above the upper surface of the plate D, is tightly rammed down on to the top of the plate and is surmounted by a stratum of, say, 2 inches of sand F, covered by a layer G of heavy fire brick. The stratum of sand F and the layer of firebrick G not only protect the carbonaceous material from the fire, but serve to weight the carbonaceous material down upon the plate.

The treating compartment B is heated by the flames and hot products of combustion from the fire chamber H, which are led upward through the flues H^1 and directed inward over the tops of the treating compartment and finally discharged into the chimney or smokestack H^2.

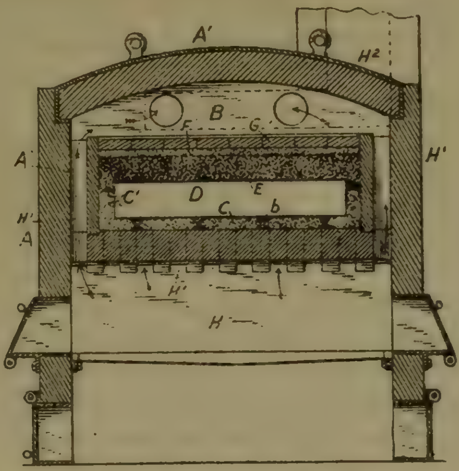
With a furnace of the character shown in the drawings a period of about forty-eight hours will be required to bring up the heat to the required point, and such heat will be required to be kept up about one hundred and twenty hours. A further period of four or five hours will ordinarily be required after the fire has been drawn to remove the plate from the furnace and have it cool down to the desired dull red color. The spraying operation will be required to be continuously kept up for a period of about four hours in order to effect and preserve the chilling of the supercarburized surface until the remainder of the plate has become perfectly cool. A plate of 10½ inches in thickness thus treated will be found to be excessively hardened upon its supercarburized surface and at the same time to be remarkably tenacious, so that a hardened projectile of, say, 6 inches diameter, weighing 100 pounds, fired at it with a striking velocity of 2,000 feet per second, will be shivered to fragments without deeply penetrating the plate. The extreme point of the projectile, which may slightly penetrate the plate, will be found to be welded thereto by the great heat resulting from the sudden stoppage of the projectile in its flight.

Owing to the great tenacity and the heterogeneous crystalline structure of the supercarburized and hardened stratum, its tough backing, and the entire homogeneity of the plate from one surface to the other, except as to its crystalline structure, there will be no cracking off of the hardened exterior stratum and no complete piercing of the plate by the projectile. In these particulars the plate will be found to differ in a marked degree from all armor plates heretofore known.

THE TRESIDDER PROCESS.

The treatment employed at the Atlas Steel Works, Sheffield, England, is described in the English patent specifications, taken out by the inventor, Capt. T. J. Tresidder, as follows, reference being made to Plate XVII:

In development of the process for which Patent No. 12347 was granted to me on the 12th September, 1887, and with the view of hardening the face of an armor plate or of improving its molecular structure throughout, I heat it and then chill one or both of its surfaces with water, oil, or other suitable fluid, projected against it under pressure from a large number of small apertures placed close together in an appa-



HARVEY PROCESS for treating ARMOR PLATES

Engineering News

FIG. 1.

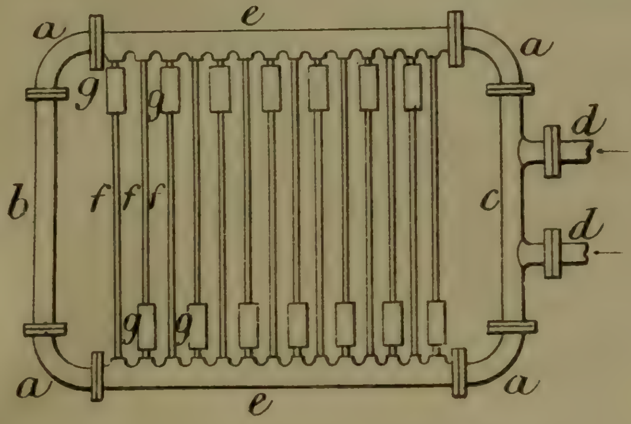


FIG. 4.

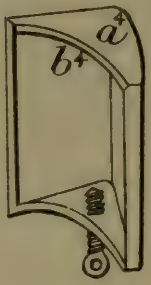


FIG. 2.

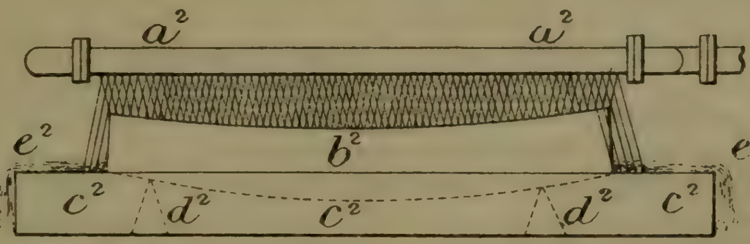


FIG. 3.

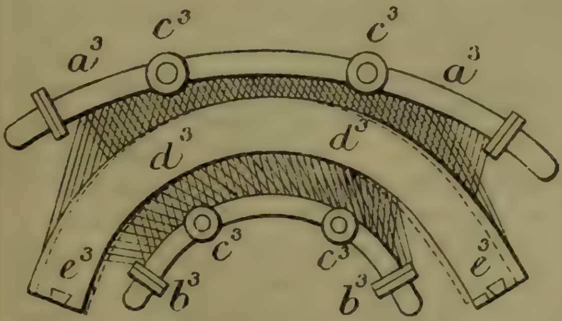
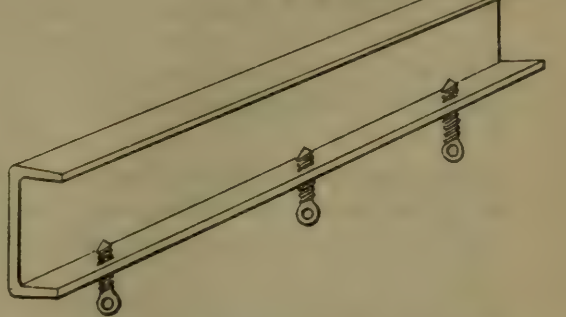


FIG. 5.



TRESIDDER PROCESS for treating ARMOR PLATES

Patent Specifications

ratus constructed for the purpose. I have found by actual experiment on a large scale that plates treated with water in this way are superior as regards resistance to projectiles to untreated plates or to plates quenched with oil in the ordinary manner. The treatment may or may not be followed by annealing or tempering according to the degree of hardness required.

This invention is suggested by the theory that the unsatisfactory action of a water bath in hardening pieces of steel of large bulk is due principally to the formation of a steam envelope round the immersed article, which envelope being continually broken and reformed during the early stages of quenching only allows the heat to be abstracted spasmodically instead of with the uniformity which is the first requisite for a successful result; that the superior action of an oil bath is due not to the chemical composition of oil but to the absence of this steam envelope; and that the improvement in the action of a water bath due to the addition thereto of glycerine or of any substance tending to raise the boiling point is to be explained in the same way.

The object of this invention, therefore, is to so apply water in quenching steel that the formation of a steam envelope shall be impossible; but I do not limit myself to the use of water alone, as my process has the contingent advantage of allowing any fluid gas or vapor to be uniformly applied to one side only of an armor plate or similar article which would not be possible by immersion in a bath unless the surface to be treated happened to be perfectly flat.

By this invention I obtain (1) intense hardness and tenacity in the faces of compound armor plates (steel faced with iron backs), (2) intense hardness and tenacity in the faces of compound steel armor plates (all steel with or without nickel, etc., with high carbon faces and mild backs, whether built up or made originally homogeneous and subsequently "converted" on one side), and (3) increased tenacity and toughness, such as has hitherto been obtained by oil-hardening followed by annealing, in homogeneous steel armor plates whether containing chrome, nickel, or other such ingredients or not. The injurious and commonly fatal internal strains induced in a large mass of steel by quenching it in a water bath are entirely avoided by my process, which at the same time retains all the valuable properties inherent to water quenching.

The apparatus which I employ in carrying out my invention consists of a gridiron of parallel pipes with a surface as large as, or larger than, the armor plate to be treated.

The pipes may be three-quarters of an inch in diameter and spaced at a distance from center to center of, say, 1½ inches.

Along each pipe is a row of perforations by which jets of water may issue. The perforations may be, say, 1 inch apart and one-eighth of an inch in diameter, and should be drilled with a little obliquity alternately to right and left to better distribute the cooling medium.

The pipes are connected with a suitable source by which, whilst they are in use, water under a high pressure preferably not less than 80 pounds to the square inch is supplied to them. The number, size, and arrangement of the supply pipes is such that the pressure may reach all the jets with great uniformity.

The armor plate suitably heated in accordance with the quality of the metal is supported in a horizontal position parallel to the face of the gridiron and at a few inches distance below it.

The water is then turned on and the high pressure of the jets causes the water to be brought into contact with the surface of the armor plate without assuming the spheroidal state, while their uniform distribution insures an absolutely uniform chilling, a result never heretofore attained.

When it is desired to chill both faces of the plate, two similar gridirons are employed; they are set parallel the one to the other, and equidistant from the armor plate which is between them.

I attach much importance to the horizontal position of the armor plate during treatment and the downward vertical action of the douche, for if the douche acted upwards, only the actual points on which the jets impinged would be chilled, and if the plate were placed vertically or sloping the flow over its surface would be greater at one part than another. In either case there would be interference with that complete synchronous uniformity of treatment of every part of the surface which it is my great object to attain.

In place of water other fluids, both liquid and æreform, are sometimes employed.

The action of the water douche on high carbon steels is, as might be expected, to produce intense hardness. As the carbon is lower the hardening becomes less marked, but an appreciable hardening or stiffening effect is produced with steels containing as little as two-tenths of 1 per cent of carbon. In such a case the effect of the treatment resembles that obtained by hardening a steel of somewhat higher carbon in oil at, say, 1,600° F. and then annealing at, say, 900° F. The wet air has a milder action, (on large masses) about that of oil-hardening at 1,300° F. and annealing at 1,200° F. Dry air, especially hot dry air, has the mildest effect of all, but the uniform distribution of the cooling action peculiar to this invention always results in improving the steel.

My method of procedure is the following:

(1) If the plate to be treated is a compound plate (steel face and iron back) to finish approximately flat (as belt plates) I make it and machine it in the usual way, except that I use false templates to which to bend it. These false templates are constructed from the designer's templates, as will be described further on. When the plate is finished, as far as regards all machine work to the steel portion, all holes (if there be any, such as those tapped in the top edges of belt plates for the deck attachment) in the steel are plugged with flush wrought-iron screw plugs, arranged so as to be withdrawn with facility, similarly any keyways in the edges, if in the steel portion, are fitted with temporary keys. The plate is then carefully heated in a furnace to a "hardening heat," which will of course vary with the nature of the steel; ordinarily a moderate red heat will suffice. When hot enough it is taken from the furnace and deposited steel side up on four supports in a large flat tray (see Fig. 2) in such a way that the edge of the tray is everywhere a little higher than the bottom of the plate. An apparatus, which I call a douche, consisting of a system of pipes, perforated with a large number of small holes, in connection with a water supply (Figs. 1 and 2), is then brought up and supported a little above the plate, and the water is turned on. At first the water quenches the steel side only, but in a few moments the tray becomes full and forms a bath to the lower iron side. The object of this is to reduce the warping of the plate, which it does by about one-half. It also tends to assist the chilling action of the douche above, but the soft iron on which it acts is not affected. If the utmost possible degree of hardness is desired the douching is continued till the plate is cold, but I sometimes stop the water after all redness has disappeared, throw on the plate some scraps of soft alloy, and turn on the water again as soon as these scraps show signs of melting. In this way, by using alloys of suitable melting points, the plate can be tempered with great nicety to any required degree. When the plate is cold it will be found to have its proper finished shape if the false templates have been correctly made and worked to. The temporary plugs and keys (if any) can then be withdrawn and the bolt holes drilled and tapped in the back to complete the plate. No correction whatever of the edges should be required, but if a little proves necessary I employ an emory wheel mounted in the tool box of a planing machine, and independently driven, as a planing tool. In order to prevent too great rapidity of cooling at the corners of the plate I sometimes attach thereto iron shoes (Fig. 4) which modify the chilling action of the water at those parts. In special cases the edges of the plate also may be protected in a similar manner (Fig. 5) even to the extent of keeping them soft enough to be machined.

(2) If the plate to be finished is a compound plate (steel face and iron back) to be finished with considerable curvature (as a turret or conning tower plate, etc.) I proceed exactly as described above, except that instead of a tray I use a second douching apparatus to cool the under side of the plate (Fig. 3). This acts upwards, but it must be remembered in all cases that the douche which is to harden the plate is at its best advantage when acting directly downwards.

(3) If the plate to be treated is a compound steel plate in which the back is of so mild a nature as to undergo water quenching without losing toughness, the double douche as described for a curved compound plate may be used; but if it is undesirable to quench the back then the downward douche on the face only, without any tray to hold the water up against the back, is to be preferred. In this last case the false templates will require to be differently designed, as described further on. Another method is to use the double douche with water above the plate, and air or wet air below.

(4) If the plate to be treated is a homogeneous steel plate requiring toughness throughout rather than a hard face, either the double douche or the single douche with tray will be efficient, and false templates are not very important in such a case since the plate can be "set" after treatment without heating. But in a case of this kind I prefer to use a double douche of wet air applied in the same way as the water. The air is wetted by passing through a chamber into which tiny jets of water are allowed to play or by the method described in my patent 12347 of 1887, and it then passes into a box, one side of which is full of perforations or into the same douche as described for use with water or other fluid.

Repeated experiments have shown that the warping produced by quenching a straight plate 9 or 10 inches thick from one side only is of a uniform convexity towards the quenched side, and that the amount of convexity is about three-eighths inch in a distance of 4 feet; also that the warping of a steel-faced compound plate of the same thickness quenched from both sides is similar in nature but less in extent, being at the rate of about one-fourth inch in a distance of 4 feet. Homogeneous steel plates equally quenched from both sides after being uniformly heated have no tendency to warp. Experiment has also shown that by bending a flat plate till it is concave on the side to be hardened to an extent determined in the manner above specified, its flatness will be restored by the warp due to quenching. Thus plates to be treated by this process must be originally bent with less convexity on the hard side than ultimately required, and the proper form for the false templates previously alluded to can be arrived at approximately by applying one of the corrections given above and with accuracy after a few trials with the particular kind of plate to be treated. Thin plates warp more than thick ones. A plate 4 inches thick shows a convexity of one-half inch in four feet when hardened on one side only.

As regards the water pressure to be used I prefer a high pressure, say 80 pounds to the square inch, but this depends greatly upon the area of the surface to be treated. In any case there must be sufficient volume of water to cause a brisk flow from all the apertures of the douching apparatus. For the air or wet air quenching a pressure of about 10 pounds to the inch will suffice.

In cases where it is not desirable to let the water run to waste, or where the douching apparatus is employed with special fluids which are of value, arrangements can easily be made for catching the fluid as it falls from the plate and conveying it to a tank to be pumped and used over again.

The action of the water douche on high carbon steel is, as might be expected, to produce intense hardness. As the carbon is lower the hardening becomes less marked, but an appreciable hardening or stiffening effect is produced with steels containing as little as two-tenths of 1 per cent of carbon. In such a case the effect of the treatment resembles that obtained by hardening a steel of somewhat higher carbon in oil at say, 1,600° F. and then annealing at, say, 900° F. The wet air has a milder action (on large masses) about that of oil hardening at 1,300° F., and annealing at

1,200° F. Dry air, especially hot dry air, has the mildest effect of all, but the uniform distribution of the cooling action peculiar to this invention always results in improving the steel.

In the drawings annexed, Plate XVII, Fig. 1 is a plan of the douche apparatus.

a a a a are 4-inch quarter bends with flanges; *b* is a 4-inch straight pipe; *c* is a 4-inch pipe with two 4-inch flanged paps; *d d* are 4-inch connections from water service; *e e* are 4-inch pipes cast with numerous paps for 1-inch screw connections; *f f f* are 1-inch cross pipes; *g g* are long unions for cross pipes. These pipes are full of ⅛-inch perforations on under side drilled at various angles to spread the flow of water. Several douches of different sizes are to be provided. Some flat as above, and others more or less curved.

Fig. 2 is a side elevation of single douche, armor plate and tray for flat plates or plates of slight curvature.

a^2 a^2 is the douche; b^2 is the armor plate bent concave to finish flat; c^2 c^2 c^2 is the tray to hold water up against back of plate; d^2 d^2 are supports on which plate rests (cast iron pyramids); e^2 e^2 water overflowing edges of tray and running to waste. × one of the water inlets.

If the water or other cooling medium is not to be wasted an overflow pipe to this tray would be provided. The level of this overflow would depend on whether the cooling medium was required to touch back of plate or not.

Fig. 3 is an end elevation of curved plate and double douche.

a^3 a^3 is the upper douche for hardening; b^3 b^3 is the lower douche for moderating the warp; c^3 c^3 c^3 c^3 are the water inlets; d^3 d^3 is the curved armor plate to finish to quicker curvature as dotted. The full line shows the curve of the false template and the dotted line that of the designer's template. e^3 e^3 are the keyways in edges temporarily filled up.

Fig. 4 shows a shoe with clamping screw, to attach to corners of plate when required, to prevent too rapid cooling of corners. The top a^4 rests on top of plate and the clamping screw bites on under surface. It is cast iron about 1 inch thick and beveled to ¼ inch at edge b^4, which is curved as shown.

Fig. 5 shows an edge guard with clamping screws to attach to edges of plates, when required to check chilling of edges. This will be straight or curved as required. The upper flange rests on top of plate, and the clamping screws bite on the under surface.

CELLULOSE.

The following notes on cellulose will be found interesting from the fact that the different experiments detailed were carried out with unloaded, high-explosive, and powder-charged shells, thus showing the action of cellulose under various conditions of attack.

The comparative merits of bagged and loose material are also illustrated in the United States experiments.

AUSTRIA.

The Austrian experiments have resulted adversely to cellulose, and a substitute for it as an obturating material is now being searched for.

DENMARK.

HEKLA CELLULOSE FIRING-TRIALS, MAY 1, 1891.

Although this experiment was briefly referred to on page 176, No. X, it is here given more in detail, as being of interest in comparison

Fig 1

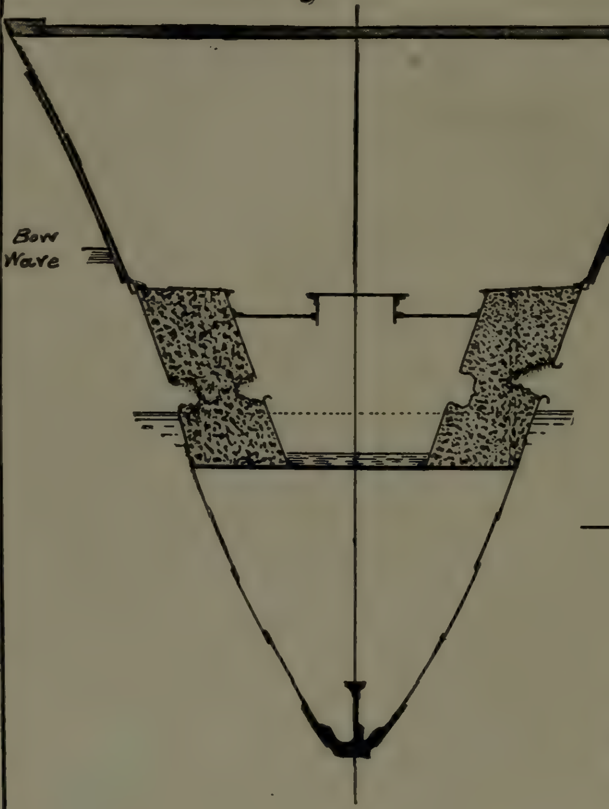
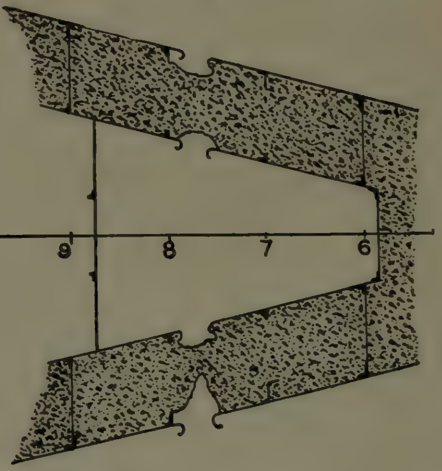


Fig 2



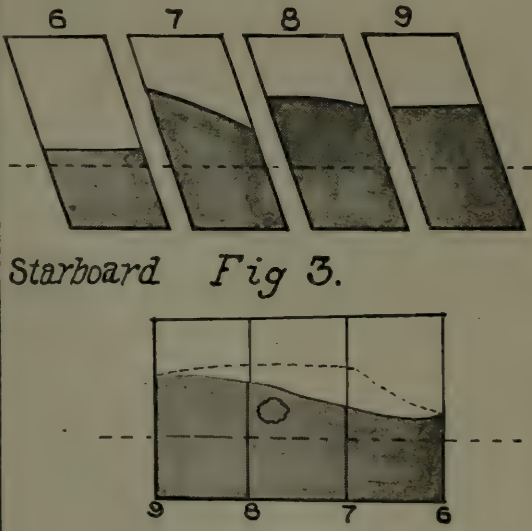


Fig 3.

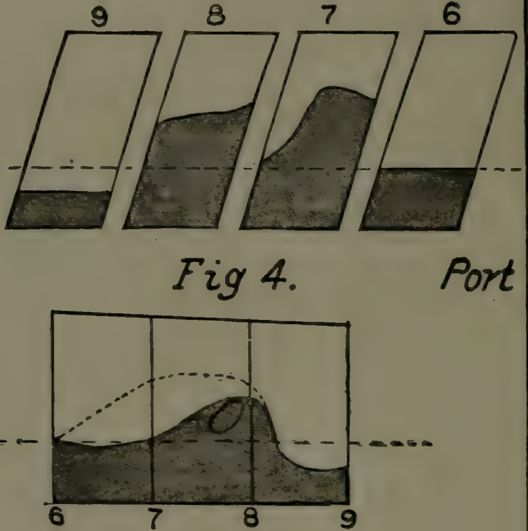


Fig 4.

HEKLA CELLULOSE TEST.

with the below-mentioned trials, in which loaded shells were used. (See Plate XVIII.)

The *Hekla*, drawing 10 feet forward and 11 feet aft, was anchored in from 3 to 3½ fathoms of water in Laltholm Bay, and the firing was done from the cruiser *Absalon*, at a distance of 100 feet. Both vessels employed their moorings and a tug to hold them in position. The preparations made on board the *Hekla* consisted of: (1) A target was marked on the starboard bow, directly under the bill-board, on the water line and including four frames. (2) On opposite sides of the deck, immediately over the target, were placed two vertical sights; in order to be sure of the projectile leaving the port side between frames, as it entered the starboard side, so as to necessitate as little repairing as possible, the gun of the *Absalon* was only to be fired when these two sights appeared in line. (3) The *Hekla* was listed to port 5°, which was the angle corresponding to the line of fire. (4) A trial target was placed forward on the stem.

The target was attacked by a 5-inch uncharged forged-steel shell, weighing 40 pounds, fired by a charge of 8 pounds cubical powder, with a striking velocity of 1365 f. s., at a range of 100 feet.

After several trial shots, a shot was fired at the target, entering the starboard side and leaving the port side 6 inches above the water line, as shown in Plates XVIII.

The vessel was then put on an even keel, and steamed full speed, 16 knots, for three consecutive hours, raising a bow wave of from 3¾ feet to 4¼ feet above the center of the shot hole. After fifty-five minutes several drops of water appeared on the inside of the starboard hole, and in sixty-five minutes on the port side; in one and one-fourth hours water appeared in the drain pipe of the port cells, and in two hours in that of the starboard cells; the flow continued to increase until the vessel had steamed for two and one-half hours, being much greater on the port or shot-outlet side, when it gradually diminished during the last half hour, after which it was considered unnecessary to continue the trial.

During the three hours, during which the holes were completely submerged by the bow wave, only 7½ cubic feet of water entered the vessel, of which 4½ cubic feet came in through the port side.

The limit between the dry and wet portions of the cellulose are shown in Figs. 1 and 2.

FRANCE.

In the French experiment with melinite shells against light armored upper works, described on page 142, a cofferdam filled with cellulose was secured behind the armor. It was composed of four similar caissons, each divided into five or six spaces, of which the sides were of corrugated sheet iron, .059 inch thick, and tops and bottoms of .118-inch sheet iron.

The results of the firings showed that the cofferdam did not resist the large calibre melinite or powder charged shells, and that when the armor was struck the obturating qualities of the cellulose were insufficient to keep the water out of the large hole produced. The cellulose was also very inflammable when attacked by large explosive shells, or even small powder-charged shells.

The recommendations of the Commission were that cellulose should not be employed in cofferdams of armored cruisers, or in any event where a penetrating projectile would not immediately be followed by water; that the cofferdams tested were too weak and should be abolished or decidedly modified; and that, considering the explosive qualities of melinite shells when they meet plates of the proper thickness, it would be better to do away entirely with the cellulose cofferdams and substitute in their stead, on the outside, a plate of iron .591 inch thick, which would cause the bursting of the projectile.

COFFERDAM TESTS IN UNITED STATES.

During February and March, 1892, experiments were conducted by a board of naval officers for the purpose of investigating the properties of cellulose, packed loose and in bags, in cofferdams.

The cofferdams were of iron, 6 feet by 6 feet by 3 feet, the front faces being $\frac{3}{8}$-inch thick, and the rear faces $\frac{3}{16}$-inch thick. The cellulose consisted of a mixture of 14 parts by weight of granular to 1 of fibrous, and was supplied by the Franco-American Cellulose Company. Two cofferdams were used, in one of which the cellulose was packed loose, and in the other in bags.

The loose cellulose dam was packed with four layers, compressed by hydraulic jacks to about one-half their original thickness, which weighed in all 808 pounds, corresponding to a density of about 0.12.

The bags used in the other dam were made of canvas, covered with a water-proof material, 3 feet long, 17 inches diameter, each containing 25 pounds cellulose pressed by hand and weighing, filled, 29½ pounds. Thirty-two bags, each compressed to a thickness of 9 inches, were required to fill the cofferdam. The bags were arranged at right angles to those of the preceding layer.

Firing tests.—The cofferdams were set up before butts at the Indian Head Proving Grounds, and supported at their backs by sand banked within a foot of their top.

Two loaded fuzed shell were fired at each dam from a service 6-inch, 40-calibre, B. L. R.; charge, 25 pounds brown prismatic powder; projectile 100 pounds, containing a bursting charge of 3½ pounds; striking velocity, 1,525 f. s.; range, 528 feet.

LOOSE CELLULOSE COFFERDAM.

No. of round.	Point of impact.			Dimensions of hole.		Depth of crater in cellulose.	Granular fiber thrown out in front.
	From bottom.	From side.					
		Right.	Left.	Width.	Height.		
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Quarts.*
1	30	....	21	6	6	18	1
2	24	15½	....	9	9	24	....
BAGGED CELLULOSE COFFERDAM.							
1	28	....	19	9½	7½	24	2
2	22	16	....	6½	6½	18	....

In all, about one-fourth ounce of cellulose was thrown out in front, but the amount thrown out at the rear could not be determined, on account of its being mixed with the sand. The craters in the rear were found, after the removal of the sand, to be from 2 inches to 3 inches in depth.

All the shells exploded in the butt, after perforation, too distant to ignite the cellulose.

The shot holes were then covered with wooden guards, and the cofferdams shipped to the Norfolk navy-yard for obturating tests.

Obturating tests.—To the front faces of the dams were clamped water-tight box fronts 1 foot deep, and to the rear faces were secured gutters under each hole, to lead what water might pass through into tubs of known capacity. The water was supplied to the box fronts through a 2½-inch hose.

Bagged cellulose.—When the water reached the level of the lower hole (second round) it immediately ran through, carrying a quantity of granular cellulose with it. It was supplied in sufficient quantity to rise to the middle of the other hole, but afterwards the leakage was equal to the supply, the obturating quality of the bagged cellulose proving to be *nil.*

Loose cellulose.—It was found that the plug used to close the second shot hole during transportation had entered 4 inches into the cellulose, and loosened and so disturbed it that the water flowed at once through the hole making a four-hour test impracticable. This hole was partially plugged, and the test confined to the other hole in which the cellulose had been less disturbed, its plug not having extended in so far. The amount of water, under a 3-foot head, that flowed each hour through this hole was: During first hour, 120 gallons; total at end of first hour, 120 gallons. During second hour, 74 gallons; total at end of second hour, 194 gallons. During third hour, 53 gallons; total at end of third hour, 247 gallons. During fourth hour, 53 gallons; total at end of fourth hour, 300 gallons. The line of demarcation between the wet and dry cellulose was found to be 20 inches below the top of the cofferdam.

The Board expressed the opinion that the obturating qualities would have been better had they been made immediately after the firing, as the dry cellulose was considerably disturbed during transportation.

Combustibility test.—An iron cylinder, 46 inches long and 15¾ inches diameter, was packed with cellulose, a hollow core 2 inches in diameter and 2 feet long being left in it. One pound of fine powder was ignited in this hollow, throwing out 4 or 5 pounds of cellulose which was charred in several places, and which burned very slowly at these points but without flames. The cellulose in the cylinder was charred in a few places, and smouldered slowly without emitting smoke or flame.

Another test was made by placing about 1 pound of cellulose on the ground under a light sheet-iron chimney, which, in the strong wind blowing at the time, produced quite a draft. The cellulose was lighted with difficulty in a number of places, and smouldered steadily but without flame. At no time during these tests did the granular cellulose burn with an appreciable flame.

The Board finished its report with the following conclusions and recommendations:

(1) The cellulose used in cofferdams for obturating purposes should be packed loose, and great care taken to obtain the required specific gravity when packed of 0.12.

(2) In packing the cofferdams compression should be obtained by means of jacks or other appliances by which the pressure is applied gradually and evenly. The cellulose should never be rammed or treated in a manner calculated to pulverize it.

(3) A thorough and uniform mixing of granular and fibrous cellulose is essential if the best results are to be obtained. To receive this it would seem desirable that the cellulose be mixed at the manufacturer's works and supplied at the shipyards ready for use.

(4) In order to insure durability of the material the cofferdam compartments must be made water-tight. The Board recommended that they be tested in the most thorough and rigid manner by repeatedly filling with water under a moderate pressure until found to be absolutely water-tight, being afterwards thoroughly painted inside and out.

(5) Although not absolutely essential, it is believed that the most satisfactory results will be obtained when the top of the cofferdam is made removable, or, in cases where this is impracticable, where there is a manhole in every frame space. Under these circumstances it is possible to obtain the requisite compression of the cellulose with much greater certainty than when one manhole must be used for filling the length of several frame spaces of the cofferdam.

FISKE POSITION FINDER

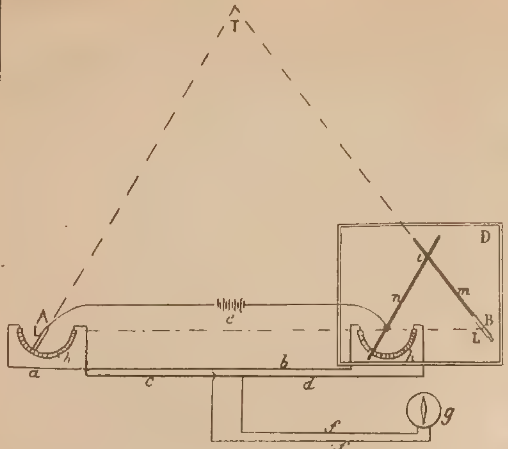


Fig. 1

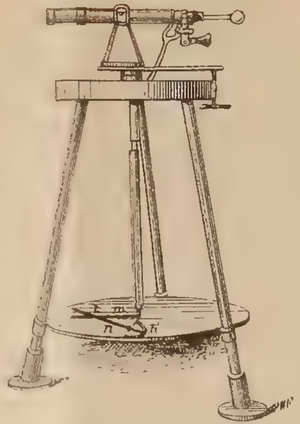


Fig. 2

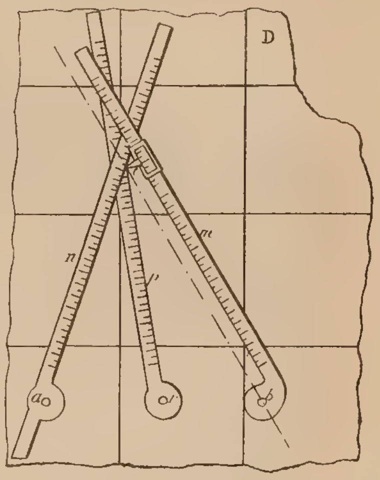


Fig. 3

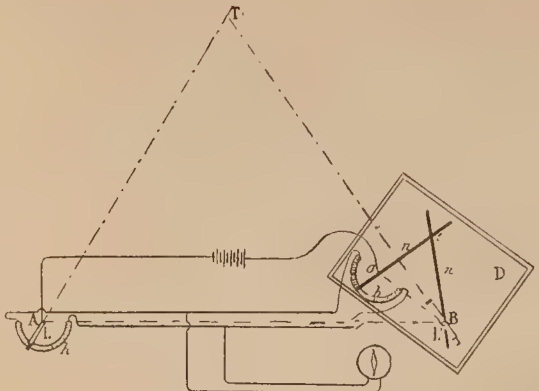


Fig 4

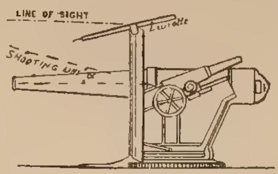


Fig. 11

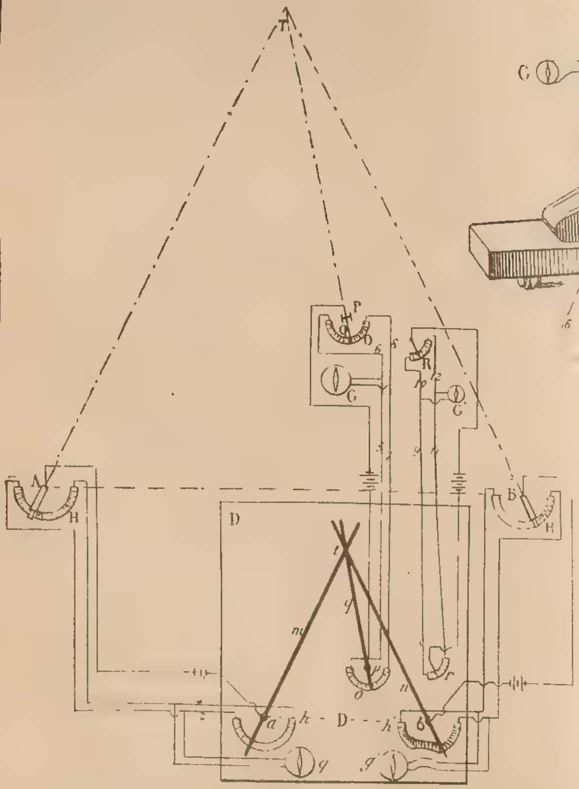


Fig. 7

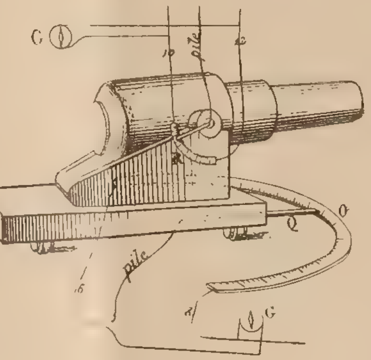


Fig. 8

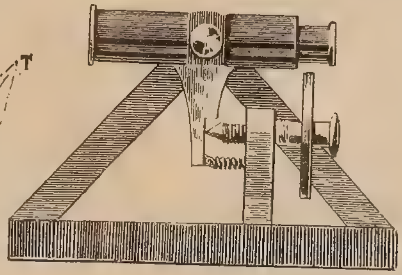


Fig. 9

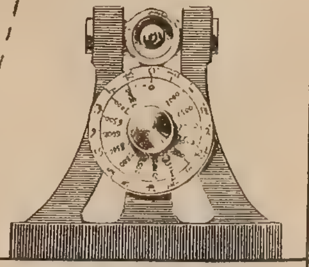


Fig. 10

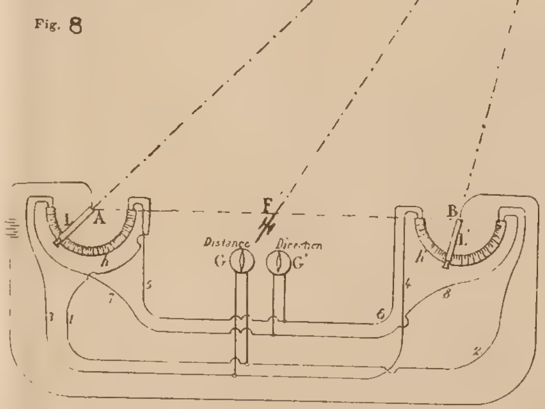


Fig. 6

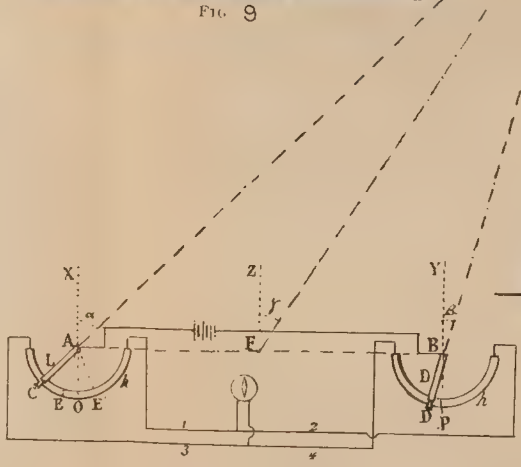


Fig. 5

ORDNANCE INSTRUMENTS.

FISKE POSITION FINDER.

Since the publication (page 97, No. IX) of the description of the range finder invented by Lieut. B. A. Fiske, U. S. Navy, he has increased the utility of his invention by applying the principles involved to a position indicator, and proposes to combine the two instruments in one apparatus.

The following excellent descriptions of his position finder, and also of a telescopic arrangement for aiming at sea, are taken from a translation in the *Army and Navy Journal* of an article by Capt. G. Moch, of the French artillery. (See Pl. XIX.)

POSITION FINDER.

This apparatus is designed to furnish, by sections, on a chart or firing platform, the position of an object. It consists of two exterior stations or observatories, indicated on the chart, and a central station in which is laid out the construction of the triangle of sections. Each observation post is furnished with an alidade with a telescope, having communication, by means of a Wheatstone bridge, with a free alidade placed in the central station; the two alidades thus arranged in this station are articulated upon pivots placed at the precise points of chart that correspond with the respective observatories. The telescopes of the observatories being directed upon the targets, the alidades of the central station are deflected by hand so as to bring the corresponding galvanometers to zero, which are disposed near them. At this moment these alidades are parallel to those of their governing telescopes. Some wires with which these are provided and which deflect automatically upon the plant indicate upon the latter the position of the target.

The arrangement may be generally simplified by utilizing one of the observation posts as the section station. This arrangement is illustrated by Figs. 1 and 2.

Fig. 2 represents, in elevation, the mechanism of station B. It consists of a tripod bearing two tables; the telescope is pivoted upon the upper one, which is perforated by a rod of the same rotation; this rod terminates below in the horizontal rule *m* placed in the vertical plane of the telescope, and which moves on the surface of the chart traced upon the lower table. Upon the latter are likewise found the second rule *n*, which should be made parallel to the vertical plane of the telescope of the other station, and the arc conductor of that rule.

Fig. 3 shows the disposition of the rules upon the plane table to avoid the uncertainty which their thickness might create as to position of their point of intersection *t*. The axis of the rule *n* is upon the extension of the graduated edge. Rule *m* carries an indicator whose point crosses the parallel to the rule passing by the axis of its pivot and marked in dots. The relation of the index point to the edge of the rule *n* shows exactly the position of the target *t*. The distance *t a* and *t b* of the latter are read in the two stations on the rules graduated by the scale of the chart. The traveling indicator has a window, in which is traced a line opposite the index in such a way as to allow reading the graduation of the arm corresponding to the latter.

A third rule *p* may be used to measure the distance from the target to a given position, for instance, to the battery; it suffices for that purpose that its pivot *r* coincides with that place on the chart that corresponds with such position.

Like the range-finder the position-finder is constructed of aluminum-bronze and iron and requires no other care than occasional cleaning. One of these instruments has been set up at Fort Hamilton, New York Harbor. It remained two months exposed to changeable weather, without any protection whatever. After this trial, it gave a series of distances ranging from 2 to 5 kilometres, with an average error of one-third of 1 per cent, or 6.6 metres for 2 kilometres, and 15.5 metres for 5 kilometres. The base measured 250 metres.

The theoretical figure furnishes a recourse when, for one cause or another, the plane table D would not have the right direction. The base A B is in such instance represented by the line B. It will be obvious that to apply all that has been previously said it suffices that the telescope L^1 and its rule *m* constitute together an angle, in horizontal projection, equal to that of the lines A B and *a* B. The triangle A T B of the plane table will be very similar to the triangle A T B of the space when the galvanometer shall mark zero, this similarity arising in reality not from the parallelism of the rule *n* and the telescope L, but from the equality which they interpret upon the corresponding arcs, arc h^1 following rigidly any displacement of the plane table.

Quite recently Lieut. Fiske has conceived a new improvement which enables him to operate his telemeter as a position-finder by automatic indications, thus very much increasing the value of the system for batteries of indirect fire. To effect this it is only essential to connect the two telescopes by a second Wheatstone bridge, which gives the direction of the object, while the first continues measuring the deviation.

Let L and L^1 be two telescopes (Fig. 5) set up in the observatories A and B, and crossing the conducting arcs *h* and h^1. They are connected by the Wheatstone bridge, 1, 2, 3, 4, governing the galvanometer G. Let C A and D B be the directions of the telescopes where they are pointed at the object T. Finally let E A be the position of telescope L, parallel to D B, and O A X and P B Y the positions of the telescopes normal to the base; the azimuthal angles of the target with A and with B are $X A T = a$ and $Y B T = b$.

When the telescopes are directed on the lines E A and D B, the galvanometer is at zero, and if telescope L is pointed on the target, following C A, the deviation of the galvanometer measures the arc E C, and, as we know, permits us to deduct the distance from the target.

We now suppose the arc *h* of 180° revolved about the base O X. The effect of this abatement will be to bring in E^1 the point E, in such manner that it will now be for the position E^1 A of this telescope L that the galvanometer will mark zero. This being so, if we direct the telescope upon the target, following C A, the deviation of the galvanometer will be proportional to the arc C E^1; that is to say, to the sum of the azimuthal angles $\frac{a+b.}{2}$ Thus by simple reading will be obtained this sum, or again the average *a* and *b*, of these angles. Now, if we consider the point F, situated upon the base, equally removed from its extremities, it is admissible without too much inexactness that the azimuthal angle Y of the target, viewed from this point, is equal to the average $\frac{a+b.}{2}$ It is easily seen that it is again necessary to assimilate the medium T F of the triangle A T B with bisecting of the angle T. This assimilation is practically quite legitimate, because the angle T, being at the most equal to 2 degrees or 3 degrees, its medium and its bisectrix make an angle of about 2 degrees.

Consequently, if a gun is placed in position F the galvanometer which in the first position of arc *h* indicated the distance of the target will actually give its direction.

It should certainly be possible to construct an instrumentation for station A, the arc of which could be reduced from 180 degrees, as has been indicated; but besides the unavoidable complication consequent it would necessitate a second observation, the return once made, and to place a double graduation on the galvanometer—a source of errors.

Fig. 6 illustrates an ingenious device by which another operation can be substituted. Instead of returning end for end arc *h* about axis O X, leaving the electric such as they are, it is sufficient to retain the arc by its position and reverse the wire of the Wheatstone bridge; the galvanometer then measures the sum and not the difference of the azimuthal angles. We are thus led to the following arrangement: The two arcs are united by two bridges, the first of which, 1, 2, 3, 4, is disposed in the usual manner, that is to say, so as to establish communication between the homologous ends of the two arcs; its galvanometer G, placed at the battery, is graduated in distances. The second bridge, 5, 6, 7, 8, on the contrary, connects the left end of the arc h with the right end of arc h^1, and reciprocally; its galvanometer G^1, equally placed in battery, measures the sum $\frac{a+b}{2}$ of the azimuthal angles; it can be graduated in values of $a + b$; that is to say, practically, in values of the azimuthal angle of the target in regard to the battery. Otherwise said, the direction of the target is read directly upon galvanometer G.

We have assumed the battery to be placed midway between the two stations simply for convenience of explanation. Moreover, it has been obvious that in thus disposing of it an unnecessary error has been effected upon the direction. It will be easy to determine between what limits the position of the battery can vary without inconvenience; in particular, it will affect the direction only favorably to bring the battery toward the bisectrix of the angle to the object; that is to say, toward the observation station nearest to the latter (the station B in the illustration). If, besides, the battery is not exactly upon the base, the distance indicated by the galvanometer will be affected by a slight error, to be determined in advance upon the ground.

ELECTRIC INSTRUMENTATION FOR INDIRECT FIRING.

Fig. 7 represents in outlined plan a system of electric aiming applicable to guns delivering indirect fire. Let P be the gun and T the object, visible only from the observatories A and B; D D is a triangulated plane table, arranged in the commanding station (which may be one of the observatories) and upon which the gun is shown at p.

In H and H^1 are two arcs furnished with telescopes and connected alidades, and in h and h^1, upon the plane table, are two other arcs, crossed by rules m and n, designed to be made parallel to the alidades of the telescopes of the posts A and B. For this effect the arcs H and h are connected between them with an electric pole and a galvanometer g by a Wheatstone bridge 1, 2, 3, 4, so that, to bring the galvanometer to zero it is necessary to render the rule m parallel to the alidades of the telescope of the post A. Arcs H and h^1 are connected by a similar arrangement.

This installation admits of determining the place of the object on the chart by displacing the rules m and n so far that the two galvanometers are at zero, the telescopes of the two posts being presumed directed upon the target.

At the emplacement p of the cannon upon the plane table is found the pivot of a reglet q, the free end of which slides on a conducting arc o. Near the gun is found another arc O, crossed by a rule Q, rigidly moving with the gun. The two arcs are connected by a Wheatstone bridge 5, 6, 7, 8, so that the galvanometer is at zero when the rule of the gun is parallel to the reglet q. It is, therefore, conceivable that where the position of the target has been indicated on the plane table, it is sufficient to cause reglet q to pass by this point, then displace the gun until galvanometer G is at zero. At this moment the gun is pointed on the target.

The angle of fire is telephoned from the central station to the gun. It can also be indicated electrically as the direction has been. For this it suffices to have a quadrometer in the commanding station, graduated in angles and furnished with an index, and at the gun an analogous quadrant, R, the two connected by a Wheatstone bridge, 9, 10, 11, 12, in the usual manner. The index of r is placed upon the desired division of graduation, after which at the gun that of R is displaced until the corresponding galvanometer at zero; at this moment the quadrant R indicates to the gunner the angle of fire.

It is only necessary to apply this apparatus to one gun of a battery and to direct the other guns under the same conditions, by any process.

The same observatories and central station can besides serve several batteries. In this case the plane table bears a corresponding number of reglet *q*, and the transmissions thence to the gun are multiplied proportionally.

The disposition of the gun is represented by Fig. 8. In front is the arc O, designed for pointing in direction, and crossed by rule Q, which is fixed to the middle of the gun carriage. The quadrant R, designed for pointing in elevation, is attached to one face of the carriage, and its index fixed on the corresponding trunnion. When the commanding station advises the battery that it has arranged the aim, the latter has only to deflect the gun in elevation and direction until the galvanometer G and G′ are at zero. The gun is then aimed.

TELESCOPIC ARRANGEMENTS FOR AIMING.

Finally, Lieut. Fiske has conceived the plan of an apparatus for facilitating the pointing of guns on shipboard, which we will describe on account of its natural interest, although it in no sense is allied to those previously spoken of.

We know what great skill in aiming on shipboard is demanded of the chief gunner in consequence of the especial difficulties resulting from the rolling of a vessel. The elevation scale being in place, the gun director takes his place behind the piece at such a distance that he is not liable to injury from the recoil. He is consequently so far from the eyepiece of the elevation scale that it is obviously difficult for him to preserve his equilibrium and at the same time retain his observation in the prolongation of the line of sight and to thus watch for firing the instant when the inclination of the ship causes this sighting line to pass before the target.

The Fiske instrument, represented in lateral elevation, and in rear view by Figs. 9 and 10, consists of a telescope, pivoted on a standard, and which a coiled spring holds in contact with an adjusting screw by means of which it can be made to assume on its axis any angle whatever with the deck of a ship.

In Fig. 11 is illustrated a gun protected by a shield turning with it; the telescope is attached to this shield at the side of the gun, and naturally points in the same direction with the latter. The screw head has a milled scale, the graduation of which is at zero when the ship has two lateral inclinations and the telescope is horizontal, or parallel to the deck. There is also marked in the same way the position of the system of aiming for which, under similar conditions, the gun is horizontal or parallel to the telescope.

If, now, it is wished to fire under an angle *a* while the ship is rolling, the piece is brought to this marked position parallel to the deck, and the adjusting screw operated so as to cause the telescope to assume an angle—*a*—with the deck. The gun director, maintaining his position by grasping with his left hand a pin projecting from the shield, keeps his eye easily at the telescope at the instant when the optical axis of the latter is about passing the target, the gun takes the angle *a* with the horizon and the chief gunner presses the firing key with his right hand and discharges the piece.

Should the rolling inclination of the ship be less than the angle *a*, the gun is given an angle with the deck at most equal to the angle of rolling, by means of the graduation traced in anticipation upon aiming system, and the complement is given to the telescope. To illustrate, the angle of fire being 6 degrees and that of rolling 4 degrees only, the gun can be set at 4 degrees from the normal position and the telescope at 2 degrees from the same.

Should the actual inclination be very feeble, or none at all, the gun can be pointed in its normal direction.

Besides this, the telescope may be installed at a remove from the gun—at the commander's station, for instance. In such case it is only essential that it be pointed in the same direction as the piece and communicates by telephone with it, to avoid all chance of error; in this condition the discharge is effected by electricity.

The telescopic system of training a gun offers still further the advantage of facilitating night firing; to effect this it carries metallic reticula which is rendered incandescent by the passage of a current, thus furnishing a line of sight by a process often utilized in astronomic observation.

A Fiske aiming telescope has given satisfactory results on board the American cruiser *Yorktown.* Another is under trial on the French cruiser *Formidable.*

ILLUMINATED NIGHT SIGHTS.

The illuminated night sight, described on page 133, No. X, was erroneously mentioned as being the invention of Canet. These sights are the invention of H. H. Grenfell, and are made, under royalty to him, by both Canet and Krupp.

The so-called "Elswick Night Sight," page 97, No. IX, is also covered by H. H. Grenfell's patents and one improvement taken out in the name of McEvoy, and this firm, also, pays a royalty to the inventors for the use of their patents.

At the close of 1891 there were 4,000 sets of night sights in use in foreign navies, all of which are made on the patents of Grenfell, or Grenfell & McEvoy.

PROJECTILES.

HADFIELD a. p.

The English Government has accepted from the Hadfield Steel Foundry Company several lots of Hadfield 6-inch chrome-steel a. p. projectiles, which they consider up to the standard of the Firth & Holtzer projectiles.

During firing trials at Shoeburyness, eleven 6-inch a. p. projectiles perforated 9 inches compound armor and from 5 to 8 feet oak backing without breaking up. During another trial, a 6-inch projectile perforated two separate 9-inch compound plates, but on its third trial, against a compound plate face-hardened by the Tressider process, it broke up.

This firm manufactures common cast-steel projectiles of from 4 to 12 inches in calibre, but as yet 6-inch is the largest calibre of their a. p. projectiles.

EDWARD SIMPSON.
Ensign, U. S. Navy.

IV.

NOTES ON NAVAL ADMINISTRATION AND PERSONNEL.

Foreign systems of naval administration and the methods followed abroad to secure efficiency of personnel and thorough preparation for war, have been treated in detail in earlier numbers of the General Information Series. The following Notes are supplementary to such special studies or record administrative measures which are of interest as illustrating tendencies of development in foreign services.

Under the conditions which obtain in Europe, where there is an ever-present and thorough conviction of the possibility of impending war, the endeavor to be prepared for its outbreak and the feeling that work looking to that end may have an early practical test, lead to earnest and sustained effort. The results, as manifested in the discussion and adoption of measures of administration, are well worthy of careful consideration.

These Notes are based mainly on foreign official publications.

ENGLAND.

INCREASE OF PERSONNEL.

The question whether the personnel of the English Navy, including both the active-service establishment and the reserves, is on such a basis as to insure an adequate supply of certain classes of officers and men in case of emergency has been earnestly discussed in England for some time past, the result being on the part of those familiar with the subject a general concurrence of opinion in the negative, though the views expressed vary greatly as to the extent of the deficiency in numbers and also as to the classes which are short.

The statement of the First Lord of the Admiralty, dated the 2d March, 1892, and submitted to Parliament in explanation of the navy estimates 1892–'93, deals with this question in a conservative spirit, but admits that there is a deficiency of lieutenants, and also of men of particular ratings.

The number of men is to be increased, such increase being incident to the additions to the fleet provided for by the Naval Defense Act of

1889. For 1892–'93, the number of officers, men, and boys, including marines, required for the active-service establishment is given officially as follows: Available for sea service, 67,712; other service, 6,388; total, 74,100. This is an increase of 3,100 over the number for the preceding year, the increase being made up of 1,350 additional seamen, 1,250 additional boys, and 500 additional marines. For 1893–'94 a further increase of 2,000 is contemplated, making a total of over 76,000 independent of reserves; in 1889, the number was 62,600.

To bring up the personnel to an equality with the matériel as it will be in 1894 the First Lord presents as necessary—

That the present annual entry of cadets into the *Britannia* be maintained, viz, 120;

That the annual entry of boys into the training ships for the next three years be not less than 3,700, the number at present proposed;

That the students at Keyham Engineering College be kept up to the present number, viz, 160;

That the artificer, fireman, and stoker classes be steadily augmented by direct entry up to 14,000; their present strength is 12,040;

That the Royal Naval Reserve be gradually raised from 22,400 to 27,000, and include in that number not less than 4,000 stokers;

That the force of Royal Marines be raised to 15,000, being an addition of 500 to the number now voted;

That the machinery for enlisting and drawing the ratings which the civilian resources of the community can be trusted to supply in an emergency, be established and kept in efficient working order.

The First Lord remarks that the estimates upon which his conclusions are based are moderate and represent a minimum standard.

It is maintained by some writers that the official programme thus outlined does not meet the case. A notable instance of this is afforded by an open letter dated the 29th April, 1892, which Admiral of the Fleet Sir Thomas Symonds has addressed to the Prime Minister. It will be recalled that the same officer pursued a somewhat similar course with reference to the matériel prior to the adoption of the Naval Defense Act of 1889. To give point to the present letter a comparison is made in it between the resources of England and France as regards personnel, and the fact is pointed out that the compulsory service system of the latter nation (pages 20, 21, and 75, No. VII, and page 316, No. IX) gives her a great advantage, while it is claimed that in England the practical test of war conditions, whenever occurring since the abolition of impressment, has shown the naval personnel to be deplorably lacking in numbers. Several instances are given in support of this appeal to the experience of the past. Sir Thomas Symonds urges a total increase of seamen and marines amounting to 50,000 men, and offers forcible arguments in support of his position. The following extracts from his letter give some of the figures on which his arguments are based:

Owing to our abolition of impressment, alterations in the navigation laws, etc., our Naval Reserve of seamen is only, during war, 23,501 partly drilled men, who have not served in ships of war. Our navy estimates, 1892–'93, give the total of our *per-*

> *sonnel* as 100,705. Eliminating 8,441 boys therein, we have 92,264 men (including reserve) all told. * * * The French have in their estimates, 1892, *Équipages*, seaman class, 42,865; reserve, 114,512; total, 157,377 to our 92,264. But far beyond numbers is the quality of the reserve. Ours has not served in ships of war, while the French are said * * * to have so served from three to five years. * * * I would propose to partly remedy the above by adding 25,000 marine artillerymen and 25,000 seamen; the latter by reëntering the pick of those of our men who have completed twelve years' service, giving them each one shilling a day beyond their pay.
>
> * * * * * * *
>
> In 1889 you laid it down as your policy that our navy should be superior to any two other navies. * * * In addition to the 157,377 seaman class the French have *troupes de la marine*, 29,015. * * * These men are not embarked during peace as part of the complement, but are evidently ready to be embarked. * * *
>
> Thus we are very inferior as regards *personnel* when compared with even a single power, whereas it is even more important that our *personnel* should be equal to that of the two strongest navies than it is that such should be the case in respect of the *matériel*.

The total of 100,705 named in these extracts includes both officers and men, and is made up of the following numbers as given in the navy estimates, 1892–'93: Available for sea service, 67,712; other services, 6,388; officers on salary for certain additional specified services, 94; Royal Naval Reserve, 23,501 (officers, 1,101; men, 22,400); Seamen and Marine Pensioners' Reserve, 3,010; total 100,705.

While it does not affect the result materially, the fact may be noted that owing to the system of stating numbers followed in the navy estimates this total does not include officers on half pay, of whom there are 279; such officers being on the active list are, of course, available for service. Incidentally it may be stated that there are 2,286 officers on retired pay, besides several hundred other officers on pension. Many of these officers would undoubtedly be available for useful duty in case of necessity.

The following extract from an article in Lord Brassey's *Naval Annual* for 1892 presents dispassionately the view that the sufficiency of the official programme in point of numbers is, at least, questionable:

> The numbers of the *personnel* are to be increased this year from 71,000 to 74,100, and next year a further increase of 2,000 men will be necessary. It may well be doubted whether this increase is sufficient. We have plenty of men to man the ships that are in commission in time of peace, but on the outbreak of war it would be difficult, if not impossible, to find complements for all our available ships—taking into consideration the fact that a considerable proportion of the Naval Reserve would be required for service on board merchant cruisers, and a large number would not be immediately available.

INQUIRY INTO NUMBERS NEEDED IN PERSONNEL.

In March, 1892, the First Lord of the Admiralty stated that a committee, of which Admiral Sir Anthony Hoskins, Senior Naval Lord at the Admiralty, was chairman, with the other naval lords as members, had undertaken the work of making an exhaustive and minute analysis of the probable wants of the English Navy in 1894, as regards numbers required in the personnel. The investigation had led to a revision of the complement and ratings of every individual ship, and of the duties to be carried out by the harbor ships in time of war.

The principles upon which this inquiry was based are of interest; they are formulated officially as follows:

(1) That the manning resources in 1894 should be sufficient for all the ships (with specified exceptions) in existence in October, 1891; of all the ships building and completing, and of the harbor ships and establishments necessary to maintain the force when on active service.

(2) That the number of active-service officers and men provided in the annual estimates should be sufficient, together with trustworthy reserves and omitting those ratings which can safely be raised in an emergency, to man, efficiently and at once, every available ship, and still leave a certain proportion to meet wastage.

(3) That no special provision for the mercantile cruisers would be necessary, except to embark officers, seamen and marines, and Royal Naval Reserve men, sufficient for gunnery purposes. The remaining parts of the complement could, in the opinion of competent judges, be obtained from ordinary sources.

(4) That the lists upon which the committee should base their calculations should be those of 1894–'95, which include the whole of the additions proposed this year and 2,000 more in the year 1893–'94.

SUSPENSION OF OPTIONAL RETIREMENT OF LIEUTENANTS.

In the more important foreign navies the principle is recognized, and applied in practice, that officers of the executive branch should not remain on the active list in certain grades after passing an age specially prescribed in the different services for each of these grades. An apparent exception may be noted in the case of the German Navy, in which, owing to its rapid growth, the officers are young for the rank they hold, and the question has not yet demanded consideration, the average age of captains, for instance, in the German Navy being but little, if any, greater than the average age of lieutenants near the head of their list in the United States Navy, though the latter are three grades lower in rank.

In accordance with the principle just mentioned, which is evidently regarded as an essential factor in maintaining a vigorous tone, officers of the English Navy who are still in the grade of lieutenant on attaining the age of 45 years must then retire on reduced pay. Officers who have not been advanced beyond that grade before reaching the age of 40 years have but very little chance of further promotion, and until recently lieutenants who were 40 years old could retire upon their own application (page 265, No. IX). Optional retirement of lieutenants has now been suspended, this being due apparently to the lack of a sufficient number of officers of this rank to meet the needs of the active service establishment.

ROYAL NAVAL RESERVE.

The Royal Naval Reserve constitutes the chief reliance of England for the immediate augmentation of the personnel of her regular navy in case of war (pages 8–14, No. VII). The efficiency of this force is therefore a matter of the highest importance. Questions connected with it have recently formed the subject of exhaustive consideration by a special committee presided over by Vice-Admiral Sir George Tryon, formerly Admiral Superintendent of Naval Reserves. This committee has made a report on the Royal Naval Reserve dated the 15th May, 1891, which has been published lately and which presents a number of points of interest.

In general terms it may be said that the main idea underlying the report is that the Royal Naval Reserve organization gives greater promise of good results than any other that has been proposed with the same end in view, and that it should be carefully fostered, strengthened, and developed. Numerous suggestions are made, and many details are pointed out wherein the present system admits of great improvement, especially as regards training.

The following statement, based on an appendix to the report, shows the sources from which the men of the Reserve are drawn, minor details as to qualifications being here omitted (pages 9 and 10, No. VII).

The First Class of the Royal Naval Reserve is recruited from men under 30 years of age who have served in the mercantile marine as A. B., or have served as skipper or second hand of fishing vessels, and also from men under 35 years of age who have served in the Royal Navy. Subject to four weeks' drill in each year.

The Second Class is recruited from men under 30 years of age who have had three years' sea service as fishermen, or as O. S. in the mercantile marine, or as apprentices. Eligible for promotion to First Class. Subject to four weeks' drill in each year.

The Third Class is recruited from boys between 15 and 16½ years of age who have had one and one-half years' training in a mercantile-marine training ship. Eligible for promotion to Second Class. Subject to four weeks' drill in each year.

Firemen are recruited from men under 45 years of age who have had six months' sea service as firemen. No drill required.

For all the foregoing classes there are special requirements as to continued service at sea until prescribed periods have elapsed.

Deferred Pension-certificate Men are men from the First-Class Reserve with at least twenty years' service (excepting men entered over 30, these with fifteen years' service).

Pensioners are Deferred Pension-certificate Men who have reached 60 years of age, or who are previously wholly incapacitated.

The report shows that the proportion of foreigners employed in the mercantile marine has increased considerably of late years. While the total tonnage has been materially augmented, the total number of British petty officers, seamen, and firemen has decreased.

Returns indicate that approximately 40,000 men in the mercantile marine are eligible to belong to the First-Class Royal Naval Reserve; of these 7,000 are enrolled. It is estimated that in the fishing industry there are engaged about 70,000 regularly and 46,000 others occasionally. From this source and from the mercantile-marine seamen not yet eligible for the First Class, 9,300 are enrolled in the Second Class, and in addition there are 1,400 skippers and second hands of the larger fishing boats enrolled in the First Class.

With reference to the utilization of this force, a matter involving the question of its available strength and its intimate connection with the regular forces, it is stated in the report that the view entertained at the Admiralty in 1885 with reference to the employ of the Reserve when called out was—

(1) That one-third of the complement of able and ordinary seamen of ships told off for commissioning, having over thirty able and ordinary seamen in all, should be filled by Royal Naval Reserve men;

(2) That thirty Royal Naval Reserve men were to be sent to each of the First Reserve ships when their complements are made up to seagoing strength;

(3) That able seamen, not seamen gunners, of the merchant cruisers should be Royal Naval Reserve men;

(4) That twenty Royal Naval Reserve men should be sent out to each of the merchant cruisers abroad in addition to their seamen gunners and petty officers.

But it is clear that all such scales must be changed from time to time.

It is not possible to form a precise opinion as to the numbers that would be available within any given time. Returns show that over 16,000 Reserve men are either at home or in near European waters. It is estimated that exclusive of the Third-Class Reserve and of firemen, 10,000 men may be held to be available for service at sea at short notice and there would be a stream of men returning from abroad thereafter.

It is recommended, in view of the conditions incident to the merchant service, that the Reserve when called out should be amalgamated with the regular service, forming a percentage of the crews of naval vessels.

Some changes have been made recently increasing the number of officers allowed. The qualifications for entry and for promotion of officers are practically the same as heretofore, except that the service required of midshipmen prior to promotion has been reduced for those who have taken the twelve months' training in a man-of-war at sea, and that second and third mates of large ocean-going passenger steamers who have had six years' service at sea and have passed an examination for master can now be admitted as sublieutenants (page 9, No. VII). The grades and the number allowed in each grade are as follows: Lieutenant, 250; sublieutenant, 420; midshipman, 300; senior engineer (recently established) and engineer, 150; assistant engineer, 150. Great importance is attached to the system of receiving officers for one year's training in the Royal Navy. Provision for additional systematic training of officers and men of the Reserve is essential.

The Third Class of the Royal Naval Reserve is not regarded as a satisfactory feature. It is found that a large number of the boys enrolled drop out. Only about 25 per cent. are promoted to the Second Class; a few join the Royal Navy. It is important that a sufficient number of the youth of the country be induced to enter the calling of seamen.

Firemen should be enrolled on lines similar to those governing the First-Class Reserve, the present force of firemen being allowed to die out.

Under present regulations it is estimated that the available resources might supply from 3,000 to 4,000 more men for the First Class. In the case of men who have served ten years in the navy the limit of time between their discharge therefrom and their entry in the First-Class Reserve, with the privilege of not being required to go to sea unless called out, should be increased from two to four years and they should be allowed to count half the time served in the navy toward qualifying for a Royal Naval Reserve pension at the age of 60.

The extent to which the Second Class could be increased can not be stated. It would be considerable, but not so large as might be supposed from the numbers employed in the fishing industry.

The extravagant and unsatisfactory results that arise from offering a bounty to tempt men to join the navy in time of war should be avoided by perfecting the organization of the Royal Naval Reserve.

The numbers actually enrolled in the Reserve are given in the report, but later data are now available. On the 31st December, 1891, the numbers of officers in the different grades, on the active list, were as follows: Lieutenants, 203; sublieutenants, 316; midshipmen, 232; engineers and assistant engineers, 127. On the 27th February, 1892, it was stated officially that there had been an additional enrollment of 11 lieutenants and 53 sublieutenants, and that there were then on the active list 124 officers who had served for various periods on board vessels of the navy. Besides the foregoing there are lists of retired and of honorary officers. For 1891 the actual numbers of men in the different classes were as follows, the numbers allowed being given also in parentheses: First class, 10,068 (9,600); second class, 9,763 (10,000); firemen, 572 (700); third class, 187 (300).

The recommendations made in the report have been generally adopted, to be put in force gradually.

It may be remarked that a system suited to the conditions in England, with a mercantile marine without parallel to draw upon, would obviously not be, in its entirety, of great value to a nation practically without such resources, although in some of its details it may be suggestive of features that would be valuable in any scheme for the establishment of a reserve force. Even in the case of England current discussion shows that it is open to question whether, should emergency arise, the Royal Naval Reserve would be able to meet fully and successfully the test of actual practical trial.

ROYAL NAVAL ARTILLERY VOLUNTEERS.

Prior to April, 1892, there were in England two volunteer reserve corps intended to supplement the regular naval force should occasion arise, viz, the Royal Naval Reserve and the Royal Naval Artillery Volunteers (pages 17 and 18, No. VII).

The second corps of naval volunteer reserves, the Royal Naval Artillery Volunteers, was composed of men who had not, as a rule, practical acquaintance with the sea, but who had nautical sympathies and aspirations. Except with their own consent, they could only be called upon for service in the defense of the home coast and its outlying islands and for service in the adjacent seas. This force, the creation of which was authorized by an act of 1873, consisted in 1891 of 66 officers and 1,849 men, a total of 1,915. While its total strength had of late shown but little change from year to year, the number of recruits enrolled in 1890 was 633, indicating a lack of stability. It has now ceased to exist.

The disbanding of the Royal Naval Artillery Volunteers was recommended by the committee presided over by Vice-Admiral Sir George Tryon, a special report, dated the 7th April, 1891, having been made on the subject. The recommendation of the committee that the corps should be discontinued was warmly antagonized, but received official approval and was carried into effect in April, 1892. The members of the corps were urged by the First Lord of the Admiralty to connect themselves, wherever practicable, with the corps of Volunteer Submarine Miners. It is doubtful whether much will be accomplished in this direction.

The following are, in substance, some of the salient points of the report on the Royal Naval Artillery Volunteers, the corps being referred to as a force still existing, as was the case at the time the report was submitted:

That successive attempts have been made, without avail, to mature a system of mobilization for war under which the Royal Naval Artillery Volunteers should have some assigned mission; in spite of the zeal, loyalty, and ability of the members of the force no sphere of usefulness has been found for it; this is due to the system and to the lack of the sailor element;

That some of the suggestions made by the commanding officers of brigades of the corps, who met under official auspices in 1889 to consider questions looking to increased efficiency, are either impracticable or involve large additional cost without prospect of satisfactory result;

That the suggestion of special drill ships, including partially manned gunboats stationed permanently near the headquarters of each brigade, would involve too great cost;

That the suggestion that officers commanding batteries be granted a higher rank than at present (the rank authorized at the time being that of sublieutenant), if adopted, might lead in time of war to difficulties attended with serious results;

That naval executive rank should only be given to officers on the active list who are qualified to perform the duties that appertain to the rank they hold, which duties they are bound to perform when called out on service involving subjection to naval discipline, that takes cognizance of failure in the due performance of assigned duties;

That the suggestion looking to the probable employment of a portion of the force in torpedo boats is really impracticable; that, considering the ordinary avocations of the members of the force, it is out of the question to rely upon them to afford even any part of the crew of a torpedo boat; "that it would not be reasonable to expect them to undertake duties that severely try even those inured to exposure at sea, duties that carry with them a responsibility that can not be adequately borne save by those well acquainted with shipping and its ways;"

That certain suggestions made by the commanding officers of brigades show that there are duties that could be undertaken by a volunteer force associated with the sea service, though not composed of seafaring men or sailors by profession;

That, in the opinion of the committee, a volunteer force organized on the lines of the Royal Marine Artillery would be able to render such service as has just been referred to, and in addition the present difficulty in providing efficient and suitable officers for the command of a battery would be satisfactorily met; that such a force, eligible for sea or land service, without any restriction as to the area of employ at sea, would be able to render service in various ways;

That the large number of changes in its membership, while the total strength of the corps increases but slightly, shows a lack of stability;

That the present system has failed to provide a force justifying the expenditure which it entails;

That a historical review of attempts to establish naval volunteer corps shows a uniform lack of success, except in the case of the existing Royal Naval Reserve, which is composed of bona fide seamen;

That whether the present system or the result obtained from the present expenditure on the force be regarded, the Royal Naval Artillery Volunteers should be disbanded; but should a corps affiliated to the Royal Marine Artillery be created, the members of the present force should be enabled to join it.

GUNNERY TRAINING ESTABLISHMENTS.

The naval gunnery training establishment with which the name *Excellent* has so long been identified has now been in operation ashore for some time, on Whale Island, at Portsmouth (page 75, No. VII). There is still a ship *Excellent* (formerly the *Handy*), and on the books of this vessel the officers and men connected with the gunnery establishment are borne, whether they belong to the regular force of the school or are under training; but a large part of the work, which continues to be thoroughly practical, is carried on ashore, where there are ample drill grounds, a large covered drill shed, a practice battery provided with guns of the different service types, brick barracks for men, and an officers' house. Most of the firing practice takes place afloat, to secure the conditions of actual service. Several vessels serve as tenders for this purpose.

At Devonport the *Cambridge* is used as a gunnery ship and has several tenders. The courses of instruction and training prescribed are practically the same as for the corresponding classes under instruction at Portsmouth (page 52, No. VII).

At Sheerness a naval gunnery establishment has been formed in connection with the existing naval barracks. It is probable that a gunnery ship will be provided for the service of this establishment.

The gunnery and torpedo specialties still remain separate (page 52, No. VII). The torpedo training ships are the *Vernon* and the *Defiance*, with their tenders.

INSTITUTION OF GENERAL DEPOTS.

The methods in use for drafting and mobilizing petty officers and others of all ratings and branches of the English naval service have been revised, and uniformity of system has been introduced at all the naval ports. The gunnery and torpedo training ships have ceased to be depots for men awaiting draft (except as regards certain special ratings), and are now training establishments pure and simple. At each port there is a general depot, to which men of all ratings and branches, except those of special ratings as just mentioned, are attached. Crews are kept told off for ships, ready for mobilization. It is intended that commodious naval barracks on shore shall be substituted, when practicable, for the old hulks designated for service as general depots and used to accommodate seamen.

CLASSIFICATION AND NOMENCLATURE OF SHIPS IN RESERVE.

Port Guard ships.—The number of ships in commission with reduced complements in English home waters has been increased by the adoption of an important administrative measure, consisting in the substitution of sea going armored ships for the old wooden hulks heretofore flying the flags of the commanders-in-chief at the naval ports. It was announced officially in March, 1892, that the project had been carried to completion and that there were then four of these armored vessels, which are termed Port Guard ships. They are kept ready for sea at very short notice, with a large portion of their officers and ship's companies on board. An additional armored ship has recently been designated for commission as a Port Guard ship.

Coast-guard ships.—The nine seagoing armored ships employed as district ships for Coast-guard and Royal Naval Reserve duties continue to be, as heretofore, kept in commission with reduced complements, ready for service at short notice (pages 5 and 28, No. VIII, and page 371, No. X). They are known as Coast-guard ships.

Fleet Reserve and Dockyard Reserve.—Heretofore all ships not in commission have formed what was technically called the Steam Reserve, which was divided into four classes (page 5, No. VIII). The First-Class Steam Reserve was composed of vessels complete in all respects for immediate commission. The rule was for ships not completed to remain under the control of the Admiral Superintendent of the dockyard. On completion they passed into the First Class of the Steam Reserve and under the Captain of the Steam Reserve (page 7, No. VIII) and on commission they came under the authority of the local Commander-in-Chief.

A change has now been effected in the system and in the nomenclature, a Fleet Reserve and a Dockyard Reserve having been constituted.

The Fleet Reserve comprises all the ships and torpedo boats not in commission which would have been placed formerly in the First-Class Steam Reserve, and at each port is under the Commander-in-Chief. The term First-Class Steam Reserve has been abolished, and instead of the Captain of the old First-Class Steam Reserve there is now a Captain of Fleet Reserve. As now organized the Fleet Reserve is separated into two parts, divisions A and B. In Division A are included ships and torpedo boats ready for mobilization or immediate commissioning. Should any ship require moderate repairs or alterations, during the completion of which she would be unfit for sudden commissioning, she is placed temporarily in Division B from the time she is taken in hand until the work is finished. Ships going out of commission after a term of service not extending beyond the usual period, will pass into the B division of the Fleet Reserve, and be under the care and control of the Commander-in-Chief, subject to any minor repairs or alterations that may be necessary from the dockyard. Recent practice would seem to indicate that such ships, when in fairly efficient condition, are not to be stripped upon going out of commission. A certain proportion of the engine-room and artisan ratings, and marines, which would be included in the full crew on commissioning, is assigned to each ship in the Fleet Reserve, for care and maintenance duties.

Vessels in Division A of the Fleet Reserve are nominally supposed to be so nearly ready for active service that an order to commission any of them could be carried out in forty-eight hours. Recent experience in several instances, as indicated by analysis of reports in the papers and journals of the time, shows that the results achieved in practice fall far short of attaining this standard.

The Dockyard Reserve includes ships refitting and those awaiting extensive repairs, and in general any ships which are to be in dockyard hands for a considerable time. Practically, it includes the former

Second, Third, and Fourth classes of the Steam Reserve (page 6, No. VIII). Any vessel of the Fleet Reserve requiring more than moderate repairs would be transferred to the Dockyard Reserve. Under the present system the Dockyard Reserve is divided into two sections or divisions, C and D, and at each dockyard is under the Admiral Superintendent, a Captain of Dockyard Reserve having immediate charge and responsibility. Obsolete ships, unfit for further service, are classed as belonging to the Dockyard Reserve.

FRANCE.

THE CHIEF OF THE NAVAL GENERAL STAFF.

Important changes were made in the central administration of the French Navy in 1890 by the suppression of the Admiralty Council, the institution of regular inspections of the fleet by General Inspectors, and the creation of a Board to select officers for promotion (pages 274 and 280, No. IX, and pages 427 and 428, No. X).

Another important step is marked by a decree of the 21st January, 1892, relating to the organization of the Naval General Staff and of the Cabinet of the Minister of Marine (pages 270 and 273, No. IX). This decree will result in a considerable concentration of power in the hands of the Chief of the Naval General Staff and will increase his authority greatly in dealing with technical naval questions, it being presupposed that he possesses the confidence of the Minister, a portion of whose authority is delegated to him, and in whose name all acts must be done. The present chief is Vice-Admiral Gervais, who has been appointed recently.

The measure is intended to give coördination and unity of purpose to all preparations for war, and as the functions of the Chief of the Naval General Staff in dealing with matters looking to rapid and successful mobilization involve great responsibility, it is considered necessary that he shall have a corresponding degree of authority.

Under the decree of the 21st January, 1892, the Chief of the Naval General Staff, who is also the Director of the Minister's Cabinet, assists the Minister in all administrative details and is immediately responsible for everything pertaining to preparation for war. Orders given by him in the name of the Minister, to whom he is accountable, must be obeyed by those to whom such orders are addressed. He may be authorized to act and to sign papers in the absence of the Minister, in all cases where the personal action of the head of the department is not specially required by law.

He is a member of the Superior Naval Council, the Board on coast defense, and the Board to select officers for promotion, and may be present with a deliberative voice, upon his request and with the Minister's approval, at the meetings of the General Inspectors, the Council of Works, and other councils and boards when he deems it necessary. Matters dealt with by these bodies are referred through him.

He has under his immediate orders all officers and others belonging to or connected with the Naval General Staff or the Minister's Cabinet, and has such authority as the Minister may delegate to him over the other directions or services of the department. He receives directly from these directions or services any information needed by him, whatever may be its nature.

The Chief of the Naval General Staff also transmits to the Minister the recommendations made by the Director of Personnel with regard to the officers to be designated for command, the officers to be promoted to the higher grades, and the assignment of such officers to duty. He receives and examines these nominations, adding indorsements himself should there be occasion. He proposes directly to the Minister the names of officers for duty on the Naval General Staff, for special missions, or for detail as naval attachés abroad.

He gives his personal supervision to the services of the Naval General Staff and of the Cabinet. In this he is aided by two assistant chiefs, both to be captains in the navy, or, at the option of the Minister, one to be a flag officer and the other a captain.

The duties of the Naval General Staff are defined in general terms in the same decree and in detail in a department order accompanying it. This order gives also the present organization of the Naval General Staff, the Minister's Cabinet, and his Private *Secrétariat*, the assignment of duties and the organization being on the same general lines as before. The Bureau of movements of the fleet is attached to the three sections of the Naval General Staff, all being under the immediate charge of an assistant chief, a flag officer or a captain. The Minister's Cabinet is under the immediate charge of the other assistant chief, a captain. The Private *Secrétariat* of the Minister is under the direct authority of the Chief of the Naval General Staff (pages 270 and 273, No. IX).

REORGANIZATION OF THE SUPERIOR NAVAL COUNCIL.

The Superior Naval Council, as originally constituted by a decree of the 5th December, 1889, was composed of nine members (page 275, No. IX). A reorganization under which there were but eight members was provided for by a decree of the 21st October, 1890. The present composition of this important council, as fixed by a decree of the 2d February, 1892, is as follows: The Minister of Marine, President; the Vice-admiral, commander-in-chief of the Squadron of the Mediterranean and of the Levant; the Vice-admiral, commander-in-chief of the Squadron of the North; the vice-admirals who have had service, in their grade, both as commander-in-chief at sea and as maritime prefect or as chief of the Naval General Staff; the five vice-admirals, commanders-in-chief, maritime prefects; the Chief of the Naval General Staff. The assistant chief of the general staff, in charge of the sections of the Naval General Staff, is attached to the council as secretary.

STATUS OF PROPOSED LAW DEALING WITH THE PERSONNEL.

The proposed law relative to the personnel which was reported to the Chamber of Deputies in May, 1891, by a special committee (page 433, No. x) was afterwards passed by that body, and since being sent to the Senate has been referred for examination to the Board of General Inspectors of the navy (page 428, No. x).

One of the main purposes of this law is the advancement of officers of the executive branch to a position of command at a reasonably early age, this being recognized as necessary, not for the benefit of individuals, but because the public interests will be served thereby. A sufficiently early training in duties involving responsibilty is seen to be absolutely essential for the officers who will command the national ships and squadrons in time of war, and the proposed law aims to accomplish this end by quickening the flow of promotion in two ways, (1) by increasing somewhat the numbers in the higher grades and (2) by lowering for several grades the corresponding ages at which retirement from the active list becomes compulsory.

Whether this particular measure be adopted or not, the report of M. Le Myre de Vilers accompanying it demonstrates the necessity for action, and some step will probably be taken in the direction indicated.

In the French Navy the officers of the executive branch, below the grade of commander, are generally older, grade for grade, than are the corresponding officers of the English, Italian, German, or Russian navies. The French officers below command rank are, however, younger than those of the corresponding grades in the Navy of the United States.

DRILLS PRESCRIBED FOR TORPEDO BOATS.

In the French Navy, as in the navies of other European powers, much attention has been given to the development of the torpedo service and to the training of specialists, officers and men, for employment therein (pages 57 and 79, No. VII). An order issued in April, 1892, prescribes a routine which is of interest as illustrating the importance attached to practical work in handling torpedo boats and manipulating torpedoes even when those charged with such duties have already passed through a special course of training. The action referred to has been taken in order that the practical exercises of the torpedo personnel in the use of automobile torpedoes shall be systematic and uniform in the different French ports.

The actual discharge of an automobile torpedo is to be practiced at least three times a month on board every torpedo boat in commission, the boat to be under way, and for two of these monthly exercises the boat must be going at high speed and a moving target is to be used.

Once in six months some of the exercises thus provided for will be carried out, so far as practicable, in a suitably chosen bay, during a cruise of the torpedo flotilla.

Precautions are to be taken to guard as far as possible against the loss of the exercise torpedoes, which are prepared at the local stations.

In addition to the foregoing, the officers commanding torpedo boats are to be exercised frequently in attacking moving objects, but without actually discharging the torpedoes. Every boat in commission is to be taken out at least twice a week for exercise. Advantage is to be taken of every opportunity for practice in piloting, and for exercising in their duties the chief petty officers by whom the commissioned officer in command is assisted in the care, management, and handling of the boat.

The mobile defense of each port (page 351, No. x) will be required to engage in at least two night sorties every month, either together or by groups. Furthermore, at least once a quarter, the mobile defense of each port is to engage in a systematic and organized general exercise; on these occasions a towboat or other suitable vessel of the port will be assigned the part of an enemy's vessel and the torpedo flotilla will be exercised in discovery, pursuit, attack, and other phases of maritime warfare.

The specialists of the torpedo personnel, officers and men, in qualifying for this service, receive practical instruction in the torpedo school which is now established on board the *Algésiras* and the *Japon.* At this school separate courses of study and practical exercises are prescribed for officers and men of different classes.

SQUADRONS IN HOME WATERS.

Serious efforts are everywhere apparent in Europe to increase the number of ships available for service at short notice and to adopt such measures as will facilitate putting them quickly on a war footing. An evidence of this is afforded by the creation of the new Squadron of the North, having two divisions, on the northern French coast, the division which was there before becoming a part of the new squadron, and the constitution of the Reserve Squadron of the Mediterranean, which now has three divisions. The naval force in French home waters now comprises the Squadron of the Mediterranean, the Squadron of the North, and the Reserve Squadron of the Mediterranean, besides vessels for various special services, and those not in condition for immediate use, and harbor ships and torpedo boats for local defense. There is also available for home service, if required, a light division in the Atlantic, which replaces the former division of the North Atlantic.

In an article in Lord Brassey's *Naval Annual* for 1892, M. Weyl says, referring to the increased number of ships in commission in the French Navy:

> * * * Under the influence of public opinion and in consequence of a vigorous discussion * * * the Government has determined to provide the fighting ships, some with complete crews, the remainder with reduced complements, but yet sufficiently numerous to insure that the mobilization of the fleet will be carried out for the future with a certainty and rapidity that has never been known before. Thus, there will be this year in the Mediterranean an effective fleet of twenty-three ships, includ-

ing nine ironclads; in the Channel a fleet of twelve ships, including six ironclads; in the Atlantic a light squadron of four cruisers; besides nineteen ships in reserve, including nine ironclads.

* * * * * * *

Every effort is being concentrated on the reorganization of the forces at home and on the defence of the seaboard, including that of Corsica, Algeria, and Tunis, where powerful flotillas of torpedo boats are about to be established.

With a view to economy, it is the present intention that during certain seasons a portion of this force shall not be maintained on its present expensive footing.

ITALY.

THE GENERAL SERVICE CORPS.

The General Service Corps (*Corpo Reale Equipaggi*) of the Italian Navy comprises that large part of the personnel which in any naval service, however organized, must be numerically far in excess of all other parts and which furnishes the specialists and others for the performance of subordinate duties. The crews of all naval vessels, including the men charged with the care of completed ships not in active service, belong to this corps, which has certain duties on shore also. The corps is recruited by voluntary enlistments and by the operation of the laws of the *leva* or compulsory military service, and includes all the men of the naval service as well as those detailed for the permanent coast defense. It includes also in all but two of its categories a special class of subordinate officers arranged in grades corresponding to those of captain, lieutenant, and sublieutenant in the army. These officers occupy a plane similar to that of warrant officers in the navy of England or in that of the United States. They serve, as a rule, in dockyards, barracks, or harbor ships, and are seldom ordered to cruising ships. When embarked they form a separate mess. They are appointed by selection from the chief petty officers of the service, who in turn have been advanced systematically in their several categories after strict examinations.

The possibility of attaining the position of an officer proves, in practice, to be a great inducement to capable petty officers to remain in the service. The officers of the General Service Corps are, however, subordinates, and should not be confused with the corps in which a higher promotion is open. To the petty officers of certain categories such advancement as to bring them in the line of the higher promotion is possible, but when this occurs their connection with the General Service Corps is severed and they enter another. This will be rendered clearer by enumerating the several corps to some one of which all persons subject to the naval code of discipline belong, viz, (1) the Corps of officers of the executive branch, (2) the General Service Corps, (3) the Naval Engineering Corps (*Genio Navale*, composed of officers of two distinct branches, one charged with duties of design and construction, and the other comprising the mechanician engineers for duty in charge of engines on board ship), (4) the Medical Corps (officers), and (5) the Pay Corps (officers). There are also civil employés who are regarded as being included in the naval personnel, though not subject to the naval code of discipline; their status need not be considered here.

The General Service Corps is commanded by an officer of flag rank and its general administration is conducted by a board of officers of the executive and of the accountant branch, presided over by the commandant. All persons belonging to the corps, when not attached to a ship or on some particular duty, are quartered in large barracks at the different naval stations. Here the men, including recruits, receive constant instruction and drill.

The force constituting the General Service Corps is divided into a number of distinct categories, each of which comprises the persons assigned to some specialty or particular field of work. Thus there are the categories of seamen, signal men, gunners, torpedo men, machinists and firemen, ship's police (masters-at-arms, etc.), artisans, musicians and buglers, nurses, and writers (including telegraphers). In each category there are certain grades or ratings, or stages of precedence through which advancement takes place from the lower to the higher. The grades or ratings in any category are assimilated with those of the other categories and with corresponding degrees of advancement in the army. This is illustrated by the following table, which gives the classification in several categories and the corresponding army classification on which it is based.

GENERAL SERVICE CORPS.

Grades and ratings in certain categories.

Seamen.	Gunners.	Torpedo men.	Machinists and firemen.	Corresponding army classification.
Captain	Captain	Captain		Captain.
Lieutenant	Lieutenant	Lieutenant		Lieutenant.
Sublieutenant	Sublieutant	Sublieutenant		Sublieutenat.
Boatswain, first class.	Chief gunner, first class.	Chief torpedo man, first class.	Machinist, first class.	Sergeant-major.
Boatswain, second class.	Chief gunner, second class.	Chief torpedo man, second class.	Machinist, second class.	Quartermaster-sergeant.
Boatswain, third class.	Chief gunner, third class.	Chief torpedo man, third class.	Machinist, third class.	First sergeant.
Second boatswain (C. B. M.).	Second chief gunner.	Second chief torpedo man.	Chief fireman	Sergeant.
Under boatswain or boatswain's mate.	Subchief gunner	Subchief torpedo man.	Subchief fireman	Corporal.
Seaman or private, further subdivided into three classes.	Gunner	Torpedo man	Fireman	Private.

The other categories, signal men, ship's police, nurses, etc., are divided into classes in exactly the same manner as are those given here.

Referring to the foregoing table, the machinist category is the only one calling for special remark. As under officers the machinists form a part of the General Service Corps, as here shown, but they are recruited from the school of *Allievi-Macchinisti* at Venice (occasionally by public competitive examination), and when advanced beyond the position of *macchinisti* of the first class they enter a branch of a corps composed of officers, the mechanician engineer branch of the *Genio Navale*, and, as officers, have charge of engines on board ship.

For purposes of administration the personnel of the different categories of the General Service Corps is grouped in four general divisions, each subdivided into two or more parts. Three of the general divisions belong to the fleet personnel, and the fourth forms the coast personnel; but the distinction implied by these terms is not strictly marked, and men of certain categories thus assigned to the coast personnel may be detailed for duty at sea. The general organization has been modified in some of its details from time to time. The status under a royal decree of the 14th May, 1891, is as follows:

Organization of the General Service Corps.

Subdivisions.	Fleet personnel.			Coast personnel.
	First division.	Second division.	Third division.	Fourth division.
First part	Seamen	Gunners and masters-at-arms.	Machinists and firemen	Seamen and signalmen.
Second part....	Signalmen and boys.	Torpedo men..........	Mechanics	Gunners, torpedo men, and masters-at-arms.
Third part......	....	....	....	Machinists, firemen, and mechanics.
Fourth part ...	....	....	....	Musicians, nurses, and prison guards.
Fifth part	....	....	....	Writers and telegraphers.

With regard to the practical result of the system of organization, classification, and advancement here outlined, in its bearing on the efficiency of the personnel, competent observers express a most favorable opinion.

PROPOSED NAVAL PROMOTION LAW.

Although minor additions and modifications have been made from time to time, the same general system of promotion has been followed, first in the Sardinian Navy and later in the Italian Navy, since 1858, and is still in force (pages 295–299, No. IX, and pp. 434–439, No. X).

In February, 1892, the Minister of Marine, Vice Admiral Saint-Bon, submitted to the Chamber of Deputies a proposed law to regulate promotions in the Italian Navy. The following outline presents in condensed form some of the principal features of this proposed law, which has been under careful consideration for the past two years and is the result of a consensus of opinion of all the different corps of the service:

CHAPTER I. *General Provisions.*—Articles 1 to 6, forming this chapter, are general in their scope. In order to become an officer citizenship is necessary. Promotion from any grade can be only to the next higher grade, and is to be by seniority or by selection, the former method being controlled by the order of precedence of names as borne on the lists, the latter depending upon a comparison of records and for some grades upon examinations also. Under either method the candidate must be recognized as fit to perform the duties of the next higher grade. When promotion to a grade is partly by seniority and partly by selection, the two methods are to be followed in turn in prescribed proportions. In computing seniority as determining promotion, deductions are to be made when an officer has been unemployed, under certain specified conditions, more than a prescribed term.

CHAPTER II. *Ordinary qualifications for promotion.*—Article 7. Promotions to the grades of admiral or vice-admiral and to that of inspector-general of the *Genio Navale* are subject to no special requirements as to service in the next lower grade.

Article 8. Except as noted in article 7, prior to promotion or advancement from a grade or rating a specified time must be passed therein. This time is as follows for each of the grades or ratings here named and for any corresponding thereto: Captain five, commander three, lieutenant-commander two, and lieutenant five years; sublieutenant, two years and six months; midshipman, one year; first-class boatswain, one year; second-class and third-class boatswain, each six months; second boatswain (C. B. M.), boatswain's mate, and seaman, each one year.

Pay cadets (grade corresponding to midshipman) must pass two years in that grade, thus forming an exception to the general rule.

Article 9. The minimum amount of sea service to be performed in certain grades prior to promotion is shown in the following table:

Grades.	Sea service required in grade.†							
	Executive branch.		Mechanician engineers.		Surgeons.		Paymasters.	
	Years.	Months	Years.	Months	Years.	Months	Years.	Months
Captain and corresponding grades	2							
Commander and corresponding grades	1	6						
Lieutenant-commander and corresponding grades	1							
Lieutenant and corresponding grades	3		3		1		1	
Sublieutenant and corresponding grades	1	6	1	6		6	1	
Midshipman and corresponding grades		9		9				6

† See the remarks following the table on page 181.

At least one year of the total sea service required in the grades of commander and lieutenant-commander, considered together, should be in command.

Article 10 gives a table showing the amount of sea service to be required in the several grades or ratings prior to promotion or advancement in the categories of the General Service Corps (*Corpo Reale Equipaggi*) detailed for sea service. This applies to boatswains of the first, second, and third classes, to second boatswains (C. B. M.), to boatswain's mates, and to seamen, and to corresponding grades or ratings, in the categories of seamen, signalmen, gunners, torpedo men, machinists and firemen, masters-at-arms, mechanics, and nurses.

Article 11. Half of the time of sea service exceeding the minimum necessary for a certain grade or rating can be counted for the next higher one, provided that three-quarters of the time established for such higher grade or rating has been performed.

Articles 12 to 14 note exemption from sea-service requirements for classes of officers not usually assigned to duty on board cruising ships, and define sea service.

CHAPTER III. *Manner of making routine promotions.*—Article 15 designates by whom nominations and promotions are to be made in the case of officers, under officers, or petty officers.

Articles 16 and 17 relate to the preparation of seniority lists.

Article 18 prescribes for every branch and grade the method by which promotions are to be made in time of peace, whether by seniority or by selection. In either case a careful consideration of the official records of candidates is an important feature for the higher as well as for the lower grades.

For officers of the executive branch the system proposed is as follows: Midshipmen to be appointed in accordance with the results of examinations [they are graduates of the Italian naval academy]. Promotion to sublieutenant to be by seniority; to lieutenant, by selection; to lieutenant-commander, half by selection and half by seniority; to commander, by selection; to captain, by selection; to higher grades, by seniority.

Article 19. If the number of officers in a grade does not exceed ten, the entire list of such grade is to be considered in making promotions from it by selection. If the number in a grade is between ten and twenty selection is restricted to the first half of the list, and if the number is greater, to the first fourth of the list of such grade.

Article 20 regulates the entry of officers into the several branches, public competitive examinations being a prominent feature. Some corps may be recruited in this way or from the naval academy. Mechanician engineer officers (*ufficiali macchinisti*) to have charge of engines on board ship are recruited from the machinist class of the General Service Corps.

It is provided that promotions to certain grades shall be preceded by competitive examinations. Promotion to lieutenant is made after such examination.

CHAPTER IV. *Promotion of officers who have not seen the usual amount of sea service.*—Articles 21 to 23, forming this chapter, provide for the promotion of specialists, the requisite amount of sea service being much less for them than for others. A limit is set, to guard against an undue number of such promotions.

CHAPTER V. *Promotion of officers not on active service.*—Article 24. Officers unattached or waiting orders can not be promoted.

Articles 25 to 27 regulate the promotion of officers on the reserved list, to whom a limited advancement is open in some cases.

CHAPTER VI. *Special clauses for time of war.*—Article 28. Under conditions of war the rules of the preceding chapters are subject to modification: (1) a reduction of one-half is then to be made in the time of service necessary in a grade and in the amount of sea service required prior to promotion; (2) promotions are to be made exclusively by selection.

Article 29. The provisions of article 28 apply only to those employed on duty counting as war service, and the Government has the option of continuing in force the promotion rules for time of peace.

Article 30. Authority may be given by royal decree to the commander-in-chief of the naval forces to make, without regard to the usual restrictions, promotions for distinguished service, or for the purpose of filling vacancies in the presence of an enemy.

Article 31 relates to promotions in the case of prisoners of war.

CHAPTER VII, the concluding one, contains additional instructions, not of general interest.

In the executive branch, under the proposed law, all promotions from the grade of sublieutenant to that of lieutenant would be by selection, instead of being two-thirds by seniority and one-third by selection, as has been the case heretofore. In promotions to the succeeding higher grades until reaching that of captain, the principle of selection would be applied to the same extent as under the old law. Officers attaining the grade of captain would thereafter be promoted by seniority instead of by selection.

The following tabular statement affords a comparison of the system under the old law and that under the one proposed, in time of peace:

Promotion of line officers, Italian Navy.

Grade promoted to—	Method of making promotions.	
	Old law.	Proposed law.
Admiral	Selection	Seniority.†
Vice-admiral	do	Do.
Rear-admiral	do	Do.
Captain	do	Selection.
Commander	do	Do.
Lieutenant-commander	One-half seniority One-half selection	One-half seniority. One-half selection.
Lieutenant	Two-thirds seniority One-third selection	Selection.
Sublieutenant	Seniority	Seniority.

† Selection to be retained for promotion to admiral. See the remarks following this table.

The outline which has been given here presents features of the proposed law as submitted to the Chamber of Deputies in February, 1892. It has now (June, 1892) been favorably reported to that body by the committee charged with its consideration, and will probably be adopted, but some modifications have been introduced by the committee. These changes, so far as they affect the foregoing outline, are as follows:

Besides the requisite of citizenship, no one to become an officer who has not attained the age of 17 years;

Promotion to the grade of admiral to be by selection from the vice-admirals who have commanded a squadron for one year, instead of being from the grade of vice-admiral by seniority without restriction as to previous service, as at first proposed;

Promotion to the grade of vice-admiral to be from that of rear-admiral by seniority, as at first proposed, but subject to the condition that rear-admirals to be eligible for promotion, must have commanded a naval division for at least six months, or must have rendered equivalent service;

Before becoming eligible for promotion the length of service required in their grade for sublieutenants and officers of corresponding grades to be two years instead of two years and six months, and for midshipmen and those of corresponding grades to be two years instead of one year;

Rear-admirals to have six months' sea service in their grade prior to promotion; midshipmen to have one year and six months' sea service in their grade prior to promotion, instead of nine months; engineers (term applied only to that branch of the *Genio Navale* charged with duties of construction and design) to have one year's sea service; except for these modifications and a few minor ones in the case of surgeons and paymasters, the sea service required in the several grades below that of vice-admiral, prior to promotion, to be as shown in the table on page 179;

Promotions by selection when made from a list of less than ten to be from any part of the list, as provided in the first form of the proposed law; when made from a larger list, to be confined to a number at the head of the list equal to ten plus one-fourth the excess the list has over ten, special provision being made for results involving fractions;

The provision suspending promotion by seniority in time of war not to be retained, but during such a period the formality of examinations to be dispensed with in making promotions by selection, such promotions being then based on meritorious war service;

Special promotions made by a commander-in-chief, under authority of royal decree, in time of war, not to be to any grade senior to that of captain.

SQUADRONS IN HOME WATERS.

The concentration of nearly all her naval strength in the Mediterranean is a characteristic feature of Italian naval policy, but few vessels being sent abroad. Another well-marked feature is the determination, apparent throughout governmental crises due to economic conditions, to maintain the standing of Italy as a naval power. The force of available vessels in home waters is organized in a Permanent Squadron, comprising three divisions, and a Reserve Squadron. There are, besides, special-service vessels, torpedo boats, etc.

A statement has been published to the effect that for the purpose of reducing expenses one division of the Permanent Squadron will probably be placed in reserve after the completion of the summer manœuvres of 1892.

GERMANY.

INCREASE OF PERSONNEL.—ADMINISTRATIVE MEASURES.

The methods adopted in Germany in dealing with the subjects which come within the scope of the notes forming the present chapter have been treated fully in previous numbers of the General Information Series. The following are some of the details of the present administrative programme as indicated by the German navy estimates for 1892–'93, the explanatory notes being taken from the same source:

A considerable increase is to be made in the number of officers and of men, one object in view being to add to the present numbers on board ships having reduced complements, a measure which is advocated as essential to thorough efficiency in case of mobilization; the scheme of mobilization excludes men on foreign stations and those needed to supply waste; crews on foreign stations are relieved every two years, annually on the West African station; the number of men needed is estimated on the basis of the requirements of the fleet in summer, that being the season when the number of ships in commission is greater than at other times, and also the season when ships on foreign stations are relieved.

Ships which have had heretofore one-third of their full complement of seamen and artisans and one-half of their engine-room force are hereafter to carry one-half of their full strength of the former and two-thirds of their war complement of the latter.

The organization of the armored vessels is to be such as to form two squadrons and a reserve division in home waters.

The institution of a South American station is to be regarded as permanent.

A special gunnery-school ship is to be devoted to training the personnel in the use of rapid-fire and machine guns. The *Hay*, a small vessel acting as a tender to the gunnery-school ship *Mars*, has now been designated for this service.

GEORGE H. PETERS,
Lieutenant, U. S. Navy.

V.

ELECTRICITY ON BOARD NAVAL VESSELS.

By Ensign JOHN J. BLANDIN, U. S. Navy.

Since the last issue of this Annual the uses to which electricity has been put on board vessels of war in our service have not materially increased in number, but important changes in the design of electrical apparatus and in the method of installation, looking to greater uniformity, efficiency, and reliability, have been made. Various devices have been and are being experimented with in a practical way in order to determine whether or not they are suited for use on board ship.

Taking the different heads under which the various electrical instruments for naval use may be grouped, a brief outline of the most important modifications in our service, and of the latest practice in our own and in foreign navies, will be given.

STANDARD APPARATUS.

During the past year an earnest effort has been made to design and definitely adopt standards, as far as practicable, for all apparatus and material for electrical installations on our naval vessels. Until recently the efforts had been directed to obtaining suitable apparatus, regardless of other considerations, and the consequence is that the electrical plant of nearly every one of the new vessels differs radically from all others, each being an improvement on all previous ones. This process of evolution has now gone so far that it is believed that the very necessary work of standardizing all material and apparatus can be safely proceeded with.

The importance of uniformity of apparatus on all naval vessels can not be overestimated, and especially in this country, where all manufacturers aim to produce standard lines of work. If special work is required it costs much more and receives much less attention, and the only remedy is to create a standard line for our purposes, thus conforming to commercial practice. In European countries this consideration is of less importance, as special work there is rather the rule of commercial practice than otherwise.

Another and more important reason for standard apparatus of all kinds for naval vessels is that fitting out and repairing, especially in an emergency, can be more easily and quickly done. Vessels on foreign stations can supply each other's wants, as a rule, when to obtain the needed material or apparatus on shore would be either impossible or very difficult.

Strange to say, the only foreign naval power that has so far given any attention to this subject is Italy, the great majority of whose vessels do their cruising near home, where they are in reach of supplies. The Italians, however, have adopted a very complete line of standard electrical apparatus for their naval vessels, and are replacing the first installations with the standard type as fast as possible. This will undoubtedly be done in our own service in the near future.

Standards have been adopted for our service for generating sets, switchboards, wire, molding, watertight fittings, fixtures, incandescent lamps, and method of wiring.

Experiments are still in progress as regards search-light projectors and lamps, electric night signals, and various means of interior communication, as the telephone, revolution indicators and telegraphs, helm indicators and telegraphs, and as regards the uses of electric motors for various purposes.

GENERATING SETS.

A standard type for generating sets has at last been adopted, based on the experience gained with past installations.

In many respects these sets are similar to those furnished to the *Newark*, *Miantonomoh*, *Vesuvius*, and *Petrel*, but with some important modifications. The principal of these are:

(1) The brushes are to remain fixed for larger changes of load.

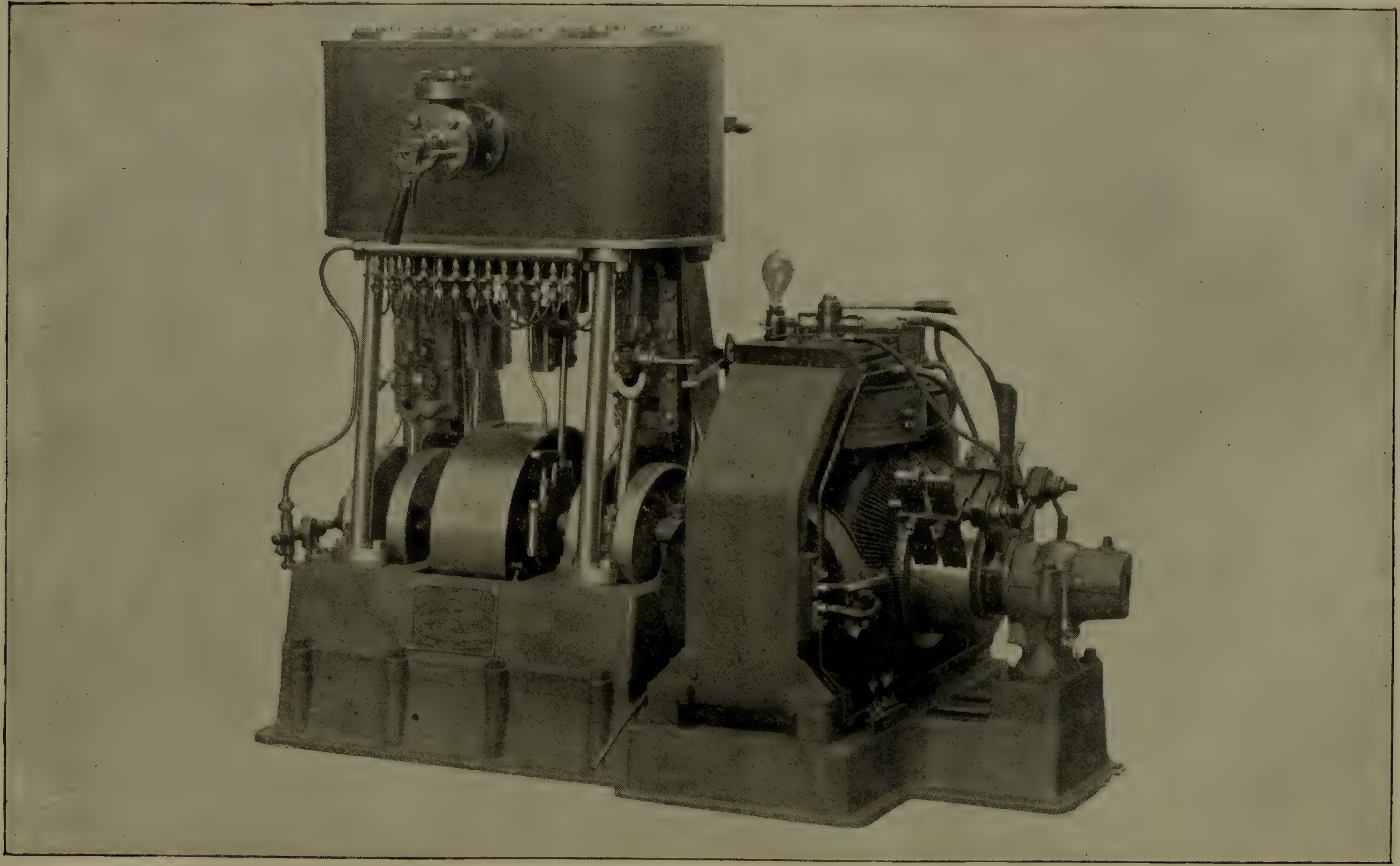
(2) The flexible coupling between engine shaft and armature shaft is to be omitted. The two shafts are now either in one, with the armature secured to a sleeve which slips over its end of the common shaft and secures with a feather; or, if separate shafts are used, they are secured together by means of a solid coupling.

(3) The stray field of the dynamo is required to be inappreciable at a distance of 25 feet.

(4) The engines are required to be run without the use of lubricants in steam spaces.

The following table shows the different standard sizes adopted, with some of the principal requirements for each:

Steam.	Speed.	Ampères.	Volts.	Weight.	Efficiency.	Dimensions.					
						Length.		Width.		Height.	
Pounds.				*Pounds.*	*Per cent.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
80	400	400	80	10,600	82	9	0	4	0	5	8
80	400	300	80	8,800	80	8	0	3	8	5	6
80	400	200	80	6,400	78	7	0	3	3	5	0
80	400	100	80	4,000	76	5	6	2	9	4	9
80	500	50	80	2,600	75	5	0	2	6	4	6



Marine Engine and Generator Combination.

The efficiency here required is that of the set, *i.e.*, the ratio of the electrical horse power at the dynamo terminals to the indicated horse power of the engine. The dimensions are the extreme measurements over all of the set complete.

Contracts have been signed for a number of generating sets to conform to the above outlined specifications. Preliminary tests on the 100 ampère sets just completed show that the engines do not regulate within the limits, but that in other respects the specifications have been met. This failure of the engines to regulate was shown to be due to the new type of governor used and not to the absence of oil in steam spaces. There is little doubt but that these sets will be successful in every way, and that they will be well adapted to the service required of them.

They are compact and light; all parts are accessible for examination or repair; no oil is used in the cylinders to be carried over into the boilers; the governing is automatic; the brushes are practically fixed for all loads; the external magnetic field is inappreciable at a distance of 15 feet; the set is strong, noiseless, free from vibration, and requires very little attention.

By the adoption of a standard type of generating set it is not intended to adopt the machines of any manufacturer to the exclusion of others. But the general type is indicated, and it is intended that the dynamos and engines of the same output shall be interchangeable.

Besides the above-mentioned sizes of generating sets, there has recently been submitted a smaller set intended for use in boats, the dynamo having a rated output of 25 ampères at 80 volts. If these dynamos are run in the open air, however, their output can safely be increased to 40 ampères, and the engine is capable of carrying that load with good regulation with 115 pounds steam presure. The following are some of the data of this set:

The dynamo has 4 poles and is compound wound. The armature is a Pacinotti-Gramme ring, 64 slots and 64 commutator segments, cross connected for 2 brushes.

The engine is a No. 3 Case engine, single cylinder, double acting and vertical. It is directly connected to the armature shaft, and the normal speed is 815 revolutions per minute.

The following are the dimensions and weights:

Floor space occupied	inches	40¼ by 23
Height	do	42⅓
Weight of dynamo	pounds	429½
Weight of engine	do	288
Weight of bed plate	do	113½
Weight of set	do	831

These sets are intended to furnish energy for search lights or diving lamps, and will be placed on steam launches, tugs, etc.

Close regulation has always been considered in this country highly desirable, if not absolutely essential, for dynamo engines. Especially is this true of the high-speed engines driving dynamos directly on board ship, where the search and incandescent lights are supplied from the same dynamos at the same time. But abroad, the throttle governor is still generally used, although close regulation with it is impossible. The following data show the difference in regulation between a Siemens-Belliss 200 ampère set and a Thomson-Houston, Armington & Sims 200 ampère set:

	Revolutions.	
	English.	American.
Normal speed	320	400
Variations on gradual change from light to full load	7	[illegible]
Variations on sudden change from full to light load	42	14

The actual regulation of the American engine was even better than these figures show, the change of speed being sharply defined without any of the "hunting" which characterized the English engine.

The reason that the throttle governor is used so extensively abroad is that the practice there is to compensate for unavoidable variations in voltage, such as those due to the heating of the dynamo, by a change in speed. In this country the practice is to use a rheostat in the shunt field for making this compensation, keeping the speed as nearly constant as possible by means of an automatic governor. In this way the running of the machines is made as nearly automatic as possible, even with large variations in steam pressure, with the additional advantage that with this system the running of compound wound dynamos in multiple, and of running search and incandescent lights from the same dynamo or group of dynamos, is made perfectly simple.

TESTING GENERATING SETS.

The tests of generating sets before acceptance have heretofore been made in each case at the factory of the manufacturer. Consequently the facilities for testing have not been of the best, and some measurements could not be made without great inconvenience. A complete plant for testing all electrical apparatus and material is now in process of construction at the New York navy-yard, where future tests will be made.

A brief description of a test may be of interest.

The test is begun with the machines at the temperature of the air. The insulation resistance of the dynamo circuits is tested with a high potential current not exceeding 1,000 volts, and measurements for insulation resistance made with either volt meter or bridge. The copper resistances of shunt, series, and armature coils are measured, noting the temperature of the room.

Each set is then started separately, and the dynamo "built up." As soon as the normal voltage is reached readings of the volt and ampère meters in the shunt field circuit are taken, and from these is calculated the resistance of the shunt coils at the temperature of the air at the begining of the run. It is important that these readings should be taken just as soon as the dynamo is built up, as the resistance increases rapidly at the start.

Having obtained these data, full load is thrown on the dynamo, and the heat run of from four to six hours, depending on the size of the dynamo, is begun. During the run the current of the dynamo is kept at the full rated amount with normal voltage, and observations are made every half hour on the current and voltage of the shunt field, noting the temperature of the room. The last readings should be taken just on stopping. As soon as the armature is at rest a thermometer, previously heated about 30° F. above the room, is placed on the armature and covered well with cotton waste. The copper resistances of the various coils are also again measured with as little delay as possible, and the insulation resistances also measured while the machine is hot. All necessary information is thus obtained in regard to the heating of various parts of the dynamo, and the insulation resistances both before and after the run.

This question of obtaining the amount of rise in temperature of the dynamo due to running, and as to the amount of rise that should be allowed, is one that has caused much discussion. The main reason that a limit is set to the rise in temperature "above that of the surrounding air" is to prevent the injury, by charring, of the insulation ot the wire of the field and armature coils. Fifty degrees F. is the limit allowed in our service, and this has not been found to be too low.

What it is desired to measure in these heat tests is the maximum temperature of the various coils, and knowing the temperature of the room at the moment of stopping, or the average about that time if there has been any change, the difference gives the "rise," which is not allowed to be more than 50° F. Simple as this appears it has given rise to more discussion than any one thing connected with the test. And the method used by the British Admiralty as laid down in their specifications is such that no approach to this information is obtained.

It has been found that the best methods for practically obtaining this rise in temperature for the shunt, series, and armature coils are—

(1) For shunt coils, by measuring the resistance at the beginning and end of the run by means of volt and ampére meters as above indicated. The per cent of increase in resistance divided by the per cent increase for one degree (0.388 % per 1° C.) gives the increase in temperature. This diminished by the increase in temperature of the room during the run gives the increase above the temperature of the room at the time of stopping.

(2) For series coil the same method is used, or fall of potential method.

(3) The temperature of the armature is best obtained by means of thermometers, though it should also be obtained by resistances as a check.

In hastily measuring such a small resistance as that of an armature errors are very apt to occur, owing principally to poor contacts, variations in resistances of leads, etc., and it has been found that a thermometer carefully handled gives the best and most uniform results. To do this requires care and patience, and the effort should be to get the highest reading possible, since the thermometer may easily reach a lower but can not reach a higher temperature than the armature. If the mercury stops rising a slight movement of the thermometer bulb may cause it to rise again.

After the heat run the dynamos are usually run, while warm, to obtain their external characteristic curve. This is taken at the speed of the engine, and is required to lie between 80 and 81 volts from full load to 10 per cent of full load, and not fall below 78 volts at no load. Indicator cards are taken at the various loads.

Further tests of the dynamo are made to see how large a movement of brushes is required for different changes of load; data for the saturation curve are taken; and with a new type or make of dynamo the engines are disconnected and tests made to separate the losses in the dynamo.

The test for the external magnetic effect of the dynamos is made by lifting a dynamo on a truck and wheeling it to some convenient place where there are no disturbing magnetic forces. Then, with the dynamo fields unexcited, the times of vibration of a horizontal magnetic needle, taken at different distances and in different directions, are noted. The fields of the dynamo are then separately excited and another set of observations taken. The effect due to the dynamo is easily calculated.

The test of the engine for governing is then made and cards taken at different loads to determine the efficiencies. With the engine running at normal steam pressure, and exhausting into the atmosphere, the load is varied both slowly and suddenly: (*a*) From full load to one-fifth load and back; (*b*) from full load to no load and back. Two per cent variation in speed is allowed in the first instance and 5 per cent variation in the second. The variation is found by taking the difference between the steady reading of the belted tachometer before the change of load and its extreme "jump," or variation, when the load is changed. The engine must steady immediately, no hunting being allowed.

These tests are repeated with vacuum exhaust, the requirements being the same.

The steam pressure is then varied from 20 pounds below the normal pressure (which is usually 80 pounds) to 20 pounds above, or from 60 to 100 pounds, with atmospheric exhaust. The variations in speed for the same load at the extreme pressures must not be greater than 2 per cent of the speed at the normal pressure.

The weight and dimensions of the set are taken.

During the runs the behavior of both dynamo and engine is noted, particularly as regards steadiness, noise, sparking, and amount of attention required.

No tests for water consumption have yet been made, on account of the great difficulty in having such tests made at the builder's factory. But upon the completion of the power and testing plant at the New York navy-yard, such tests will be made, and their results may cause the more general use of compound engines for running our dynamos. It remains to be seen, however, whether the increased efficiency in such small engines will pay for the increased weight, first cost, complexity, and extra number of spare parts required. Coumpound dynamo engines are used very generally abroad, except in Italy, and great stress is laid on the economy in water consumption.

The tests for insulation with a current of high voltage and for stray field seem to be omitted entirely abroad. The test for the governing of the engine there is not nearly so rigid as with us, and can not be so long as the throttle governor is adhered to. And the test for the heating of the dynamos required by the British Admiralty shows simply the "lagging" qualities of the covering of the wires.

NUMBER AND SIZE OF GENERATING SETS.

The total amount of electrical energy provided for a war vessel is based on the amount needed in action for all purposes, with as large a surplus as the weight and space allowed will permit.

The electrical energy required in battle is that for all search lights, for all incandescent lights on the "battle circuits," and for the ordnance motors. On the U. S. S. *New York* are to be installed three dynamos, two having an output of 400 ampères and one of 200 ampères, all at 80 volts. The total amount of current required for battle is:

	Ampères.
Search lights	360
Incandescent lights	250
Ordnance motors	190
Total	810

leaving a surplus of 190 ampères. This surplus decreases with the size of the vessel, as does also the proportionate number of lamps supplied, until a torpedo boat has a small search light with a few incandescent lamps for the machinery, and a small dynamo of just sufficient size to supply them.

In the larger vessels, where a large amount of electrical energy is needed, the question as to the number and size of the units which shall be supplied in order to furnish the required output becomes of importance. If the plant is composed of a large number of small generating sets, the weight, space, and cost are very large, but a breakdown of one set is of small importance. If a small number of large sets is installed, just the reverse of this is true. The units into which the plant is divided should, in either case, be duplicates as far as practicable.

The tendency in our service is toward installing a small number of large sets, since weight and space are the two most important factors on a modern war vessel, and should not be sacrificed except to avoid absolute danger. The necessary protection should be given the dynamos, their engines and steam piping, by suitably locating the dynamo room, rather than by dividing the plant into a large number of small units.

The loss in efficiency is not great if the usual load of a dynamo is as much as two-thirds its rated capacity, and this loss is more than compensated for by other considerations. A most important consideration is that there should always be a surplus of electrical energy, above that ordinarily required for lighting, immediately available for use in running motors, search lights, etc.

In some foreign navies the practice is to furnish dynamos of a suitable size for the search lights, each search light to be run by a separate dynamo. This is necessary, or at least desirable, when dynamos are not run in multiple, but entirely unnecessary when they are so run. The system in our service, that of running everything in multiple, renders unnecessary any relation between the capacity of the dynamos and the size of the search lights, and only requires that the engines shall be close and quick in governing, and the introduction of rheostats in the shunt field of each dynamo, and appears to be the safest and simplest system possible.

LOCATION OF DYNAMO ROOM.

The proper location of the dynamos on board ship is most important, since the use of electrical energy both for light and power, especially during action, has come to be regarded as indispensable.

The considerations which should govern the location of the dynamos may be stated as follows:

1. The security of the dynamos and their engines from external violence.
2. Short lengths and proper protection of the steam and exhaust piping of the dynamo engines.
3. A minimum effect on the compasses.
4. A central position as regards the distribution of the electrical energy.
5. Good ventilation.
6. Absence of free steam and moisture.

The dynamo room, then, should be located below the protective deck or water-line, near the boilers, and near the centre of the vessel. It should not be located directly under the conning tower if the dynamos have an appreciable external field. It should not be located in the same compartment with steam or other machinery, any injury to which would cause the dynamos to be disabled.

The exact location of the dynamo-room would have to be selected to suit the general design of each class or type of vessels, but, in general, the best location is below the protective deck just forward of the forward boilers. The only objection to this location is the proximity to the compass in the conning tower, but this is of slight importance if the external field of the dynamo is sufficiently reduced.

In merchant steamers, and in a few of the naval vessels abroad, the dynamos are located in the main engine room. This is doubtless done to save the expense of extra attendance, and to have all the machinery as concentrated as possible. But this practice is questionable, and especially under the conditions which are found on board a war vessel. The passenger steamers that are lighted by electricity usually run on fixed routes, and their electric plants are overhauled in port as often as necessary, in many cases after each trip. This is impossible on a man-of-war, as well as undesirable. No portion of the wiring on our vessels is so difficult to keep in order as that in the engine and fire-rooms; and to locate the dynamos there, exposing their insulation to the water, oil, and steam, always present when under way, and the dampness always present, would be to insure the deterioration of the insulation of the dynamos and of all conductors leading to them, and materially affect the durability of the plant.

An accident or injury to the main engines or steam piping, would probably cause the dynamos to fail, causing the lights to go out just when most needed. When in action the engine rooms are closed, the ventilation is at most no better than in the present dynamo rooms in our ships, and the danger to their insulation and to that of every circuit in the vessel, is greatest when the certainty of light is absolutely essential to safety. The dynamo room should therefore be separate from the engine room, and it would be far better to locate the dynamos just forward of the boilers in a separate room, as previously recommended.

In Europe, the practice on some large vessels is to have two dynamo rooms, one for the ordinary needs of the vessel, and the other, called the "combat" dynamo room, for use in action. The "peace" room is so located that artificial ventilation is not necessary, while the "combat" room is located well down in the vessel.

This plan has been thought favorably of in our service, but so far has not been put into practice. It has the disadvantages (1) that the total electrical energy supplied to the ship would have to be increased, thereby increasing weight, space, and cost; (2) the dynamos in the lower dynamo room would be liable not to be entirely ready for service or as efficient as if they were used more frequently. In this connection it should be said that the insulation of a dynamo on board ship, if left idle for any length of time, is very liable to be seriously impaired by moisture.

The only advantage of this arrangement is that the room that is used ordinarily is well ventilated, but experience has shown that with sufficient power properly applied the lower room can be made sufficiently comfortable.

VENTILATING SETS.

The proper ventilation of the dynamo room is very important, since if high temperatures are allowed, the health of the dynamo attendants and the insulation of the dynamos are both impaired. It has been found that by forcing fresh air into the room, lower temperatures are obtained for the same power expended, than by exhausting the hot air, and the room can readily be made comfortable. In the first vessels installed the exhaust system was used, and in some of these dynamo rooms the temperature was excessive. Since the supply system has been adopted excellent results have been obtained.

The practice now is to install in the dynamo room an electric motor directly connected to an exhauster fan. The power of the motor and size of the fan are determined by the size of the room and the length and lead of pipe through which the air has to be drawn. This exhauster draws air from deck and discharges it through one or more outlets so situated as to give the best circulation of air. When necessary a motor and blower for expelling the foul air are also furnished. The power of the motor varies from ½ to 2 H. P., and the pressure of the blast is 1½ to 2 ounces.

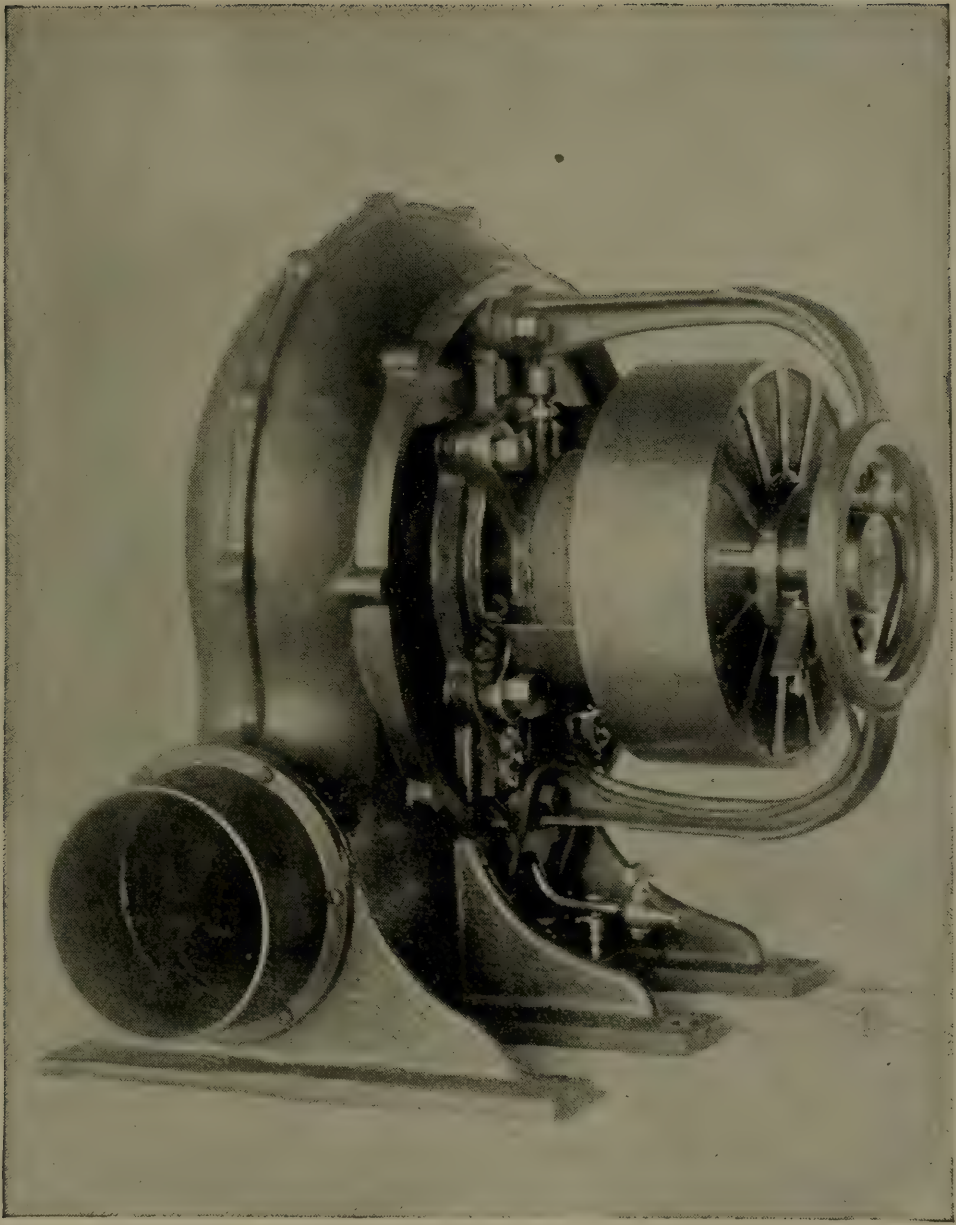
It has been suggested that this system of ventilation would be advantageous in other compartments besides the dynamo room, especially in those situated at the extreme ends of the vessel where ventilation is only required at intervals. It is thought that by this plan a gain in efficiency with a decrease in cost could be obtained over the use of the general ventilating system of the vessel.

Very recently a portable ventilating set has been designed and successfully tested. It consists of a small exhauster fan directly connected to a ¼ H. P. electric motor. The outside dimensions of this set are 14 by 18 by 17 inches, and the total weight 85 pounds. At 1813 revolutions per minute the fan delivers 368 cubic feet of air per minute at a pressure of 1 ounce, with a total expenditure of 163 watts. The efficiency of the motor is 73 per cent.

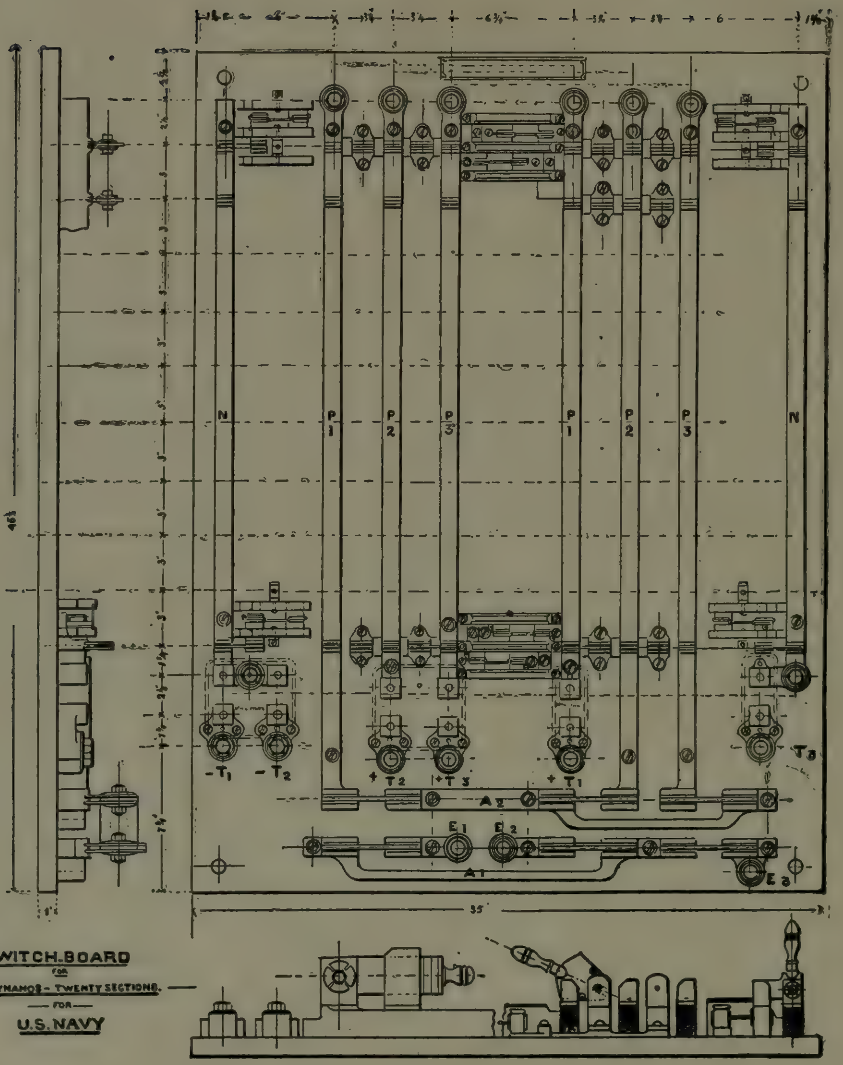
These fans are intended for use in ventilating the double bottoms and such places while they are being cleaned and painted. The set can be carried from place to place as required, and the energy can be obtained from any lamp socket.

ACCUMULATORS.

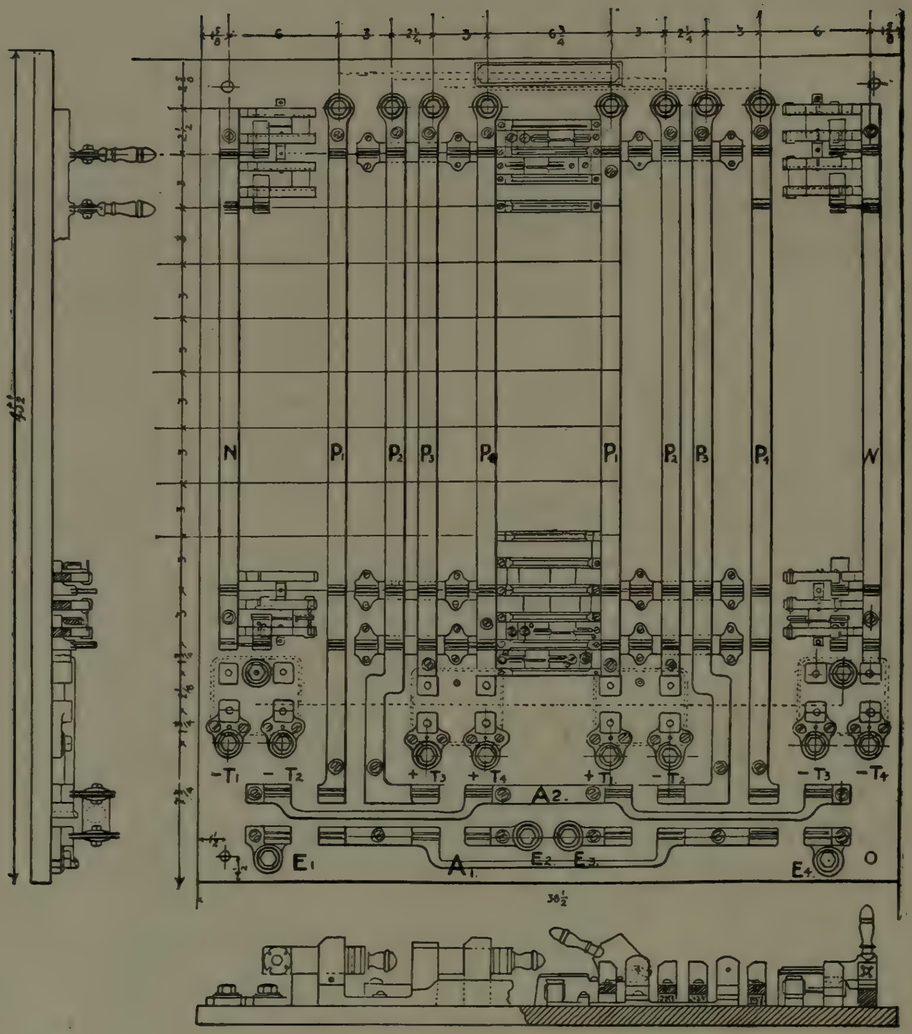
The use of accumulators on board ship continues to be looked on with little favor. The great weight and space required, together with the constant care and frequent repairs necessary, cause them to be little used. One objection to their use on board ship, though it can be guarded against, is the fact that a small amount of salt water introduced



Portable Ventilating Set.



SWITCH.BOARD
FOR
THREE DYNAMOS – TWENTY SECTIONS.
FOR
U.S. NAVY



SWITCH-BOARD
FOR
FOUR DYNAMOS – TWENTY SECTIONS
FOR
U.S.NAVY.

into a cell will quickly ruin it. Free chlorine is evolved, which readily attacks the lead plates and destroys the cell.

It has been suggested that a battery of accumulators should be installed for use in case the dynamos should be disabled. Enough might be installed to run the motors, but a supply of oil lamps or candles would better solve the problem of lighting in such an event.

PRIMARY BATTERIES.

Several forms of dry batteries have been tried on board ships for the bell and alarm circuits, but none of them have proved entirely satisfactory. The "Leclanche" form of cell is preferred for open-circuit work as being cheaper, more reliable, and easier to keep in order. For closed-circuit work the dynamo current is being used almost entirely in late installations with very satisfactory results, the voltage being reduced by using incandescent lamps for dead resistances.

SWITCH BOARDS.

A standard type of switch board has been adopted, which combines small size and weight with simplicity and flexibility in the control of individual circuits, and in making combinations of dynamos.

The accompanying cuts show the general arrangement of these boards.

N N are the common negative bars, carrying the current of all the dynamos. These are connected permanently by a cable back of the board.

P1, P2, P3, P4, are the positive bars for each dynamo, and each pair, P1 P1, P2 P2, P3 P3, P4 P4, are also permanently connected by cables.

—T1, —T2, —T3, —T4 are the connections for the cables from the negative brushes, and +T1, +T2, +T3, +T4 are the positive connections. There is a fuse between each terminal and the corresponding bus bar.

The separate section mains terminate at the back of the board, the negative leg being connected to a switch by which it is joined to the negative bus bar, and the positive leg connected to a double-throw switch, by means of which it can be thrown on either of the positive bars. Only one positive switch for each section is provided, and on boards arranged for more than two dynamos this switch has to be shifted so that it can be closed on the positive bar desired.

The bars A1, A2, connect through switches, respectively, to the terminals of the equalizing wire from each dynamo, and to the positive bus bars. Closing these switches throws the corresponding dynamos in multiple. As long as these switches are open all dynamos may be run at one time independently, and any section can be thrown on any dynamo. A section can be changed from one dynamo to another by shifting its positive switch.

These bars and switches are mounted on a slate slab. The width of this slab depends on the number of dynamos, as each dynamo has a separate pair of positive bus bars. The length of the slab depends on the number of sections. All sections, including those for motors and search lights, are connected to this board.

WIRING.

The compound rubber insulation which has been in use in our service for a number of years has in most cases given excellent results. Since the lead covering has been discarded, the question has come up as to the durability of this form of insulation for use in fire and engine rooms. Samples of wire insulated according to the following plans are now being tested thoroughly, and the style of insulation to be used in the future will depend largely on the results obtained:

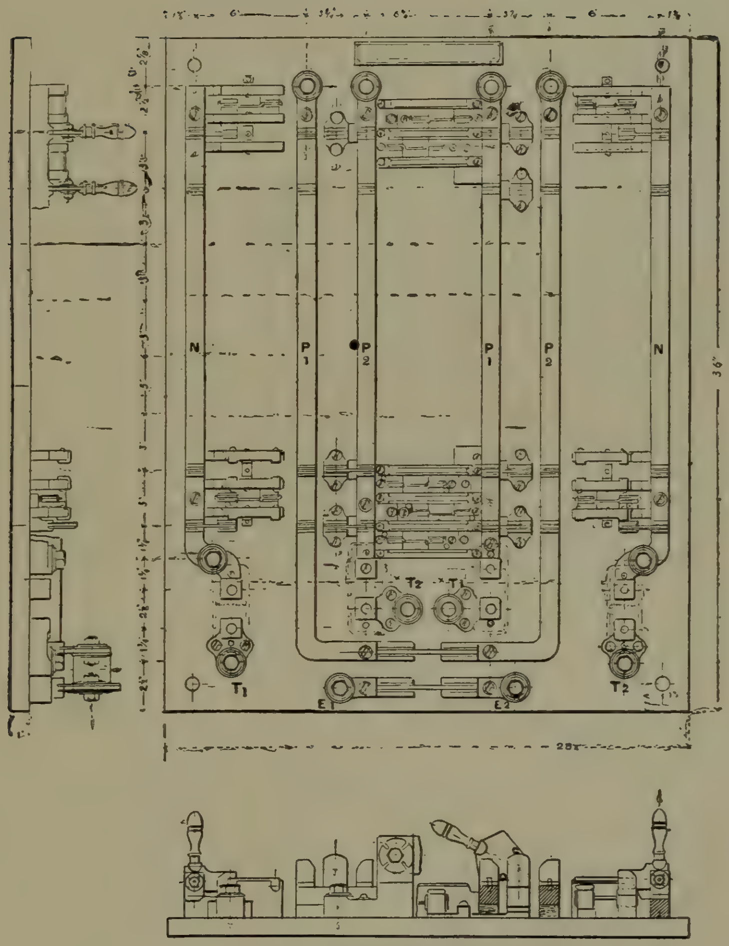
1. Solid vulcanized rubber core.
2. Compound core, consisting of—
   (*a*) Pure Para rubber.
   (*b*) White rubber separator, containing no sulphur.
   (*c*) Vulcanized rubber.
3. Compound core, consisting of—
   (*a*) Pure Para rubber.
   (*b*) Two layers of best vulcanizable rubber.
   (*c*) India-rubber coated tape. Then all vulcanized together.

The second of these is the style used almost exclusively in our vessels for a number of years past, with the addition of a cotton braid next the wire, and of a covering of pure lead. Both of these have been omitted in the latest specifications, and instead of the lead covering, a heavy braid saturated with a flame-proof compound is required. The thickness of the insulation for different sizes of wire is also specified.

There is no difficulty in getting an insulation that will test high and remain good under ordinary conditions; but our heat test, in which a length of the wire is put in an oven and raised to a temperature of 212° F. and then immersed in salt water, is the one that has not always been met. This test is necessary for wire intended for use in fire and engine rooms.

Lead covering for electric-light wires on board ship has been found to be of no advantage, while increasing the weight, cost, and labor. As a protection to inferior insulation the lead cover is doubtless valuable and even necessary, but when a good rubber insulation is used, an insulation that is not hurt by water and which really *insulates*, the lead cover is not only useless but injurious. It may have to be used in fire rooms on board ship, as the rubber insulation may have to be protected from the combination of heat and moisture there found, but in other parts of the vessel its use has been definitely abandoned.

The general method of wiring described in last year's annual is now used on all new vessels. The advantages of definitely separating the lights used in action from those used ordinarily for lighting become more pronounced the more the subject is gone into, and this method



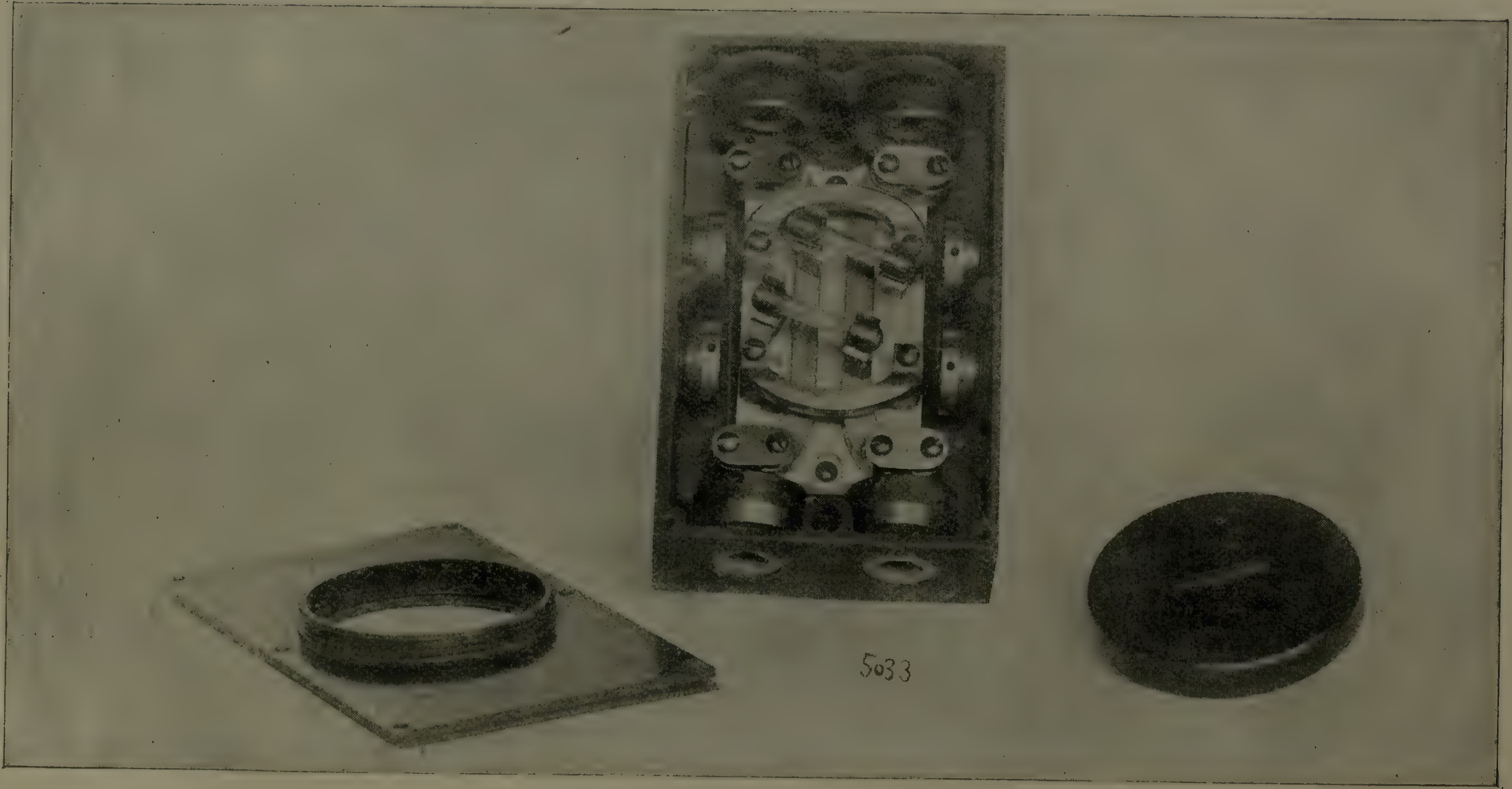
SWITCH-BOARD

FOR

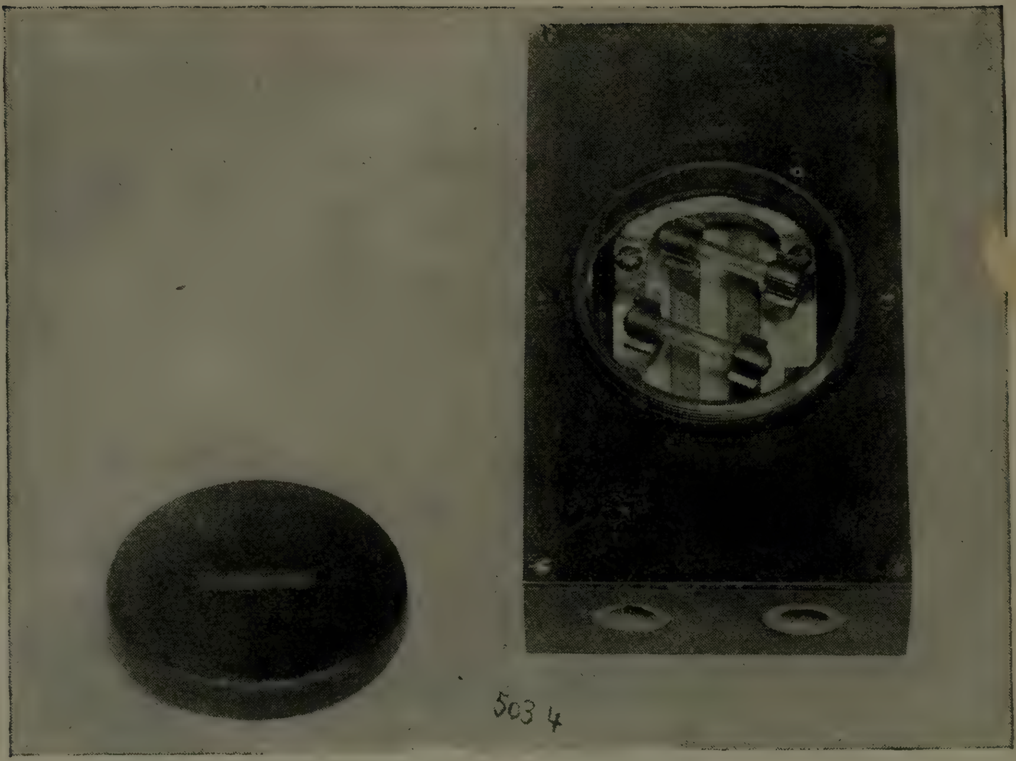
TWO DYNAMOS- SIXTEEN SECTIONS

FOR

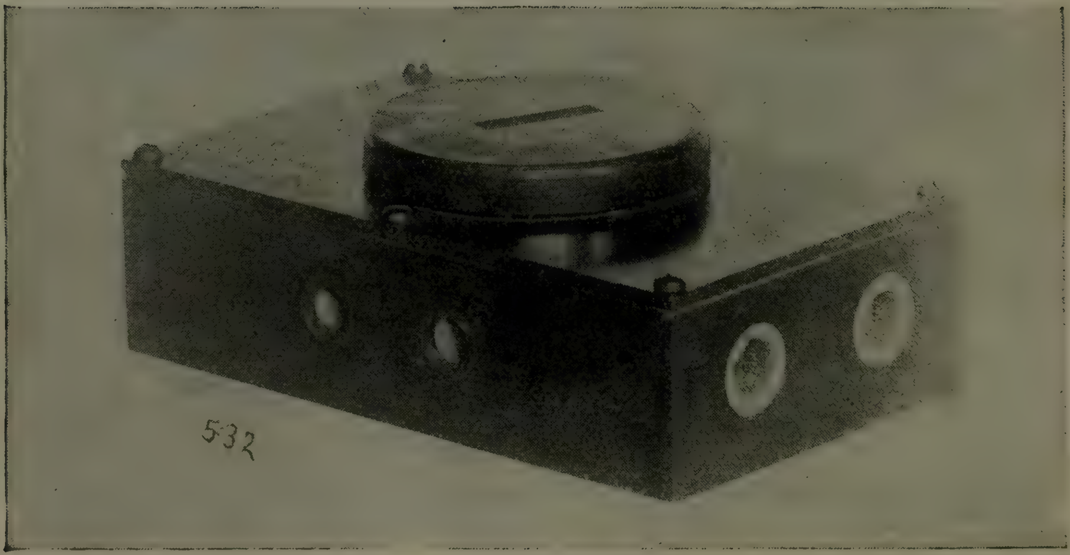
U.S NAVY



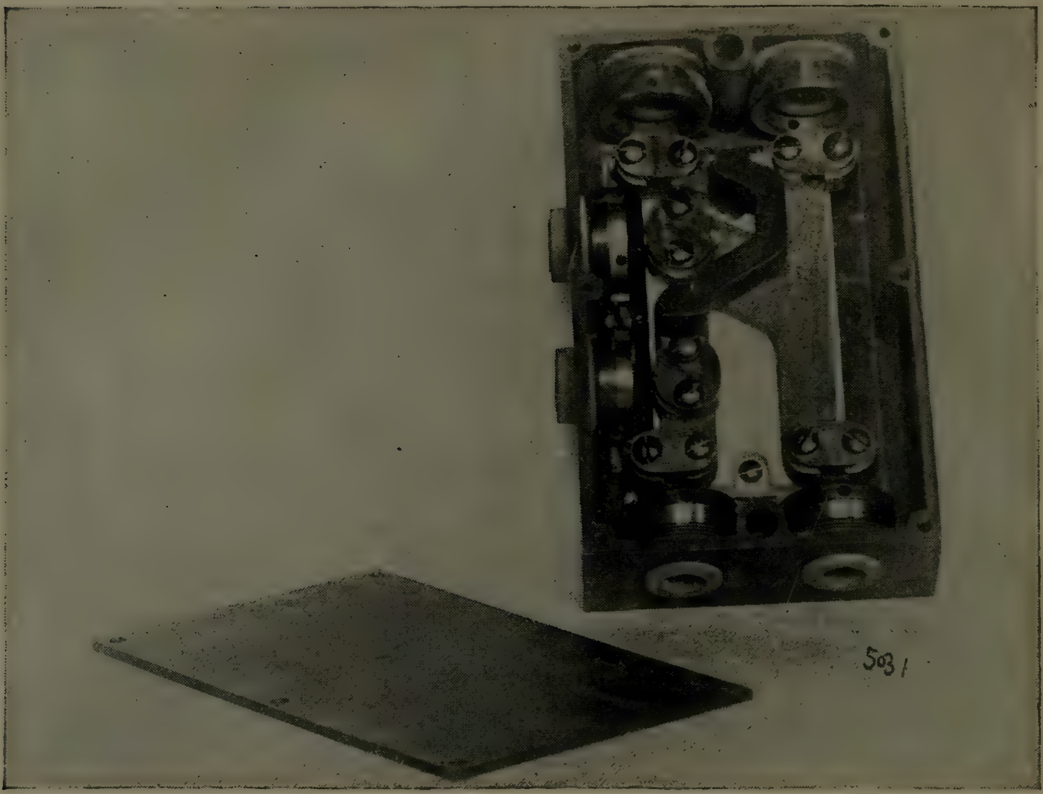
INTERIOR OF 4-WAY BRANCH JUNCTION BOX.



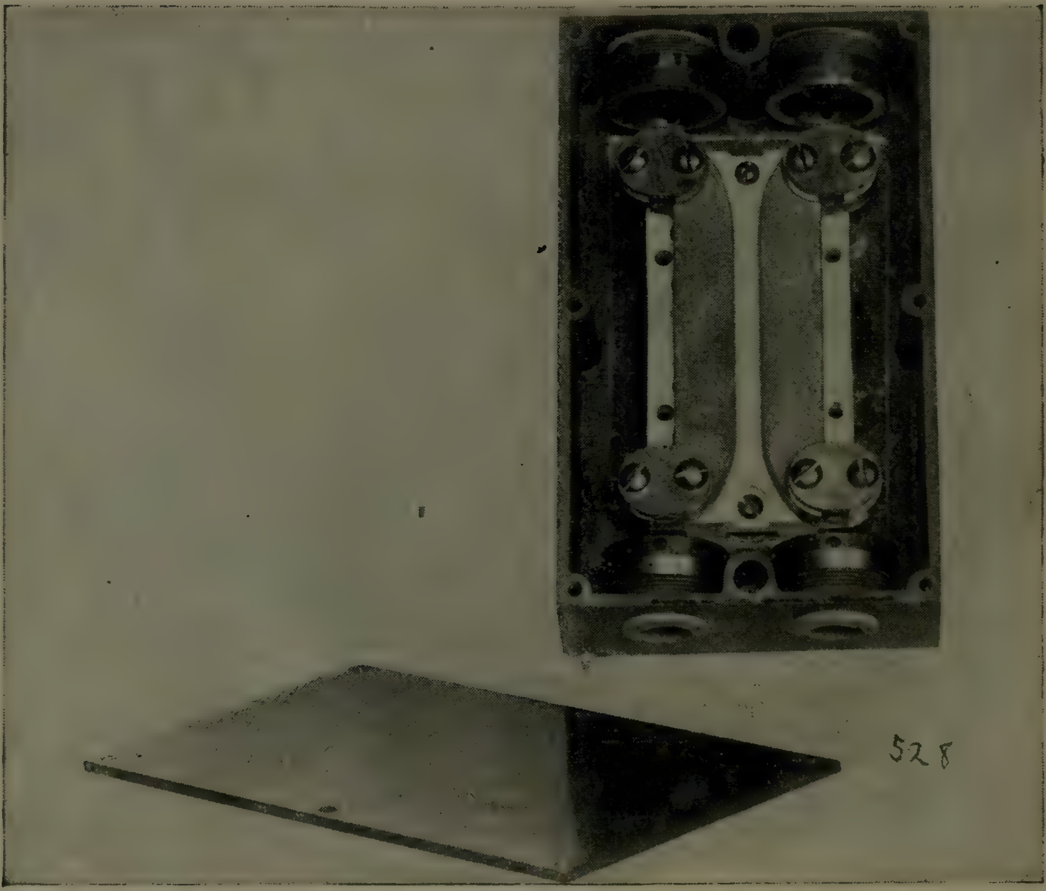
4-way Branch Junction Box.



4-way Branch Junction Box, Closed.



Feeder Junction Box.



Junction Box for Mains.

gives a decided increase in economy as well as efficiency, as less electrical energy has to be provided than would otherwise be the case.

The policy of making all joints water-tight, and of fusing all lamps is still continued. Every branch wire for each light is taken from the main out of a water-tight junction box, and is fused. The switches and receptacles are all water-tight except in officers' quarters, as also are the fixtures. The whole policy may be stated, in brief, to be to install good material in the first place with an idea of permanency, and to guard most particularly against the many enemies of an electrical installation on board ship, the principal of which is salt water.

The practice in foreign navies has generally been to use an inferior insulation for electric-light wires, of a kind that would be rendered useless if exposed to salt water. To protect the insulation the lead cover was put on. The wires, thus insulated, were very often cleated side by side directly to a steel deck or bulkhead. As the lead cover is soft and easily punctured, and as a small amount of salt water at this puncture would "ground" the wire to the vessel, this method would appear to invite disaster.

In all foreign navies, the standard of insulation and of work is being raised, and the improvements are being made in the respects where their practice differs most from ours.

The accompanying cuts show the standard wiring accessories now being used for new installations:

Plate 5033 shows a 4-way branch junction box, with the cover and cap removed. Plate 5034 shows the same box with the cover secured in place, but the cap removed and the fuses (in glass tubes) exposed. Plate 5032 shows the exterior of this box complete.

This box is similar in general design to the one now in use, with the following changes:

1. Outlets for two sets of branch wires are now provided, one on each side of the box.

2. The fuses are inclosed in glass tubes, and are held by clips, so that replacing a fuse is a simple matter. Only one pair of fuses is provided for the two branch circuits.

3. The cover is secured, as before, by six brass screws (Pl. 5034), but a screw cap in the center of the cover can be removed to allow the fuses to be easily inspected and removed.

4. The whole box, when assembled, is perfectly water-tight.

The feeder junction box (Pl. 5031), is used for connecting "feeders" to "mains"; the stuffing boxes for the feeder wires are on one side of the box, and those for the mains are on the two ends. These boxes are not fused.

The junction box for mains, or search light junction box (Pl. 5028), is used to break the continuity of long leads of wire that would otherwise be in one length. By its use shorter lengths of wire can be run, thus facilitating the work of running the wires, and of testing.

The interior blocks for all of these boxes are made of unglazed, vitreous, non-absorbent porcelain, and are all identical in size and shape. The only differences in the boxes are the number and size of the stuffing boxes provided, and in the arrangement of the interior conductors on the porcelain block. The same sizes of screws are used for the same purposes in the different boxes. In short, all parts have been made interchangeable where possible, and the number of different parts has been reduced to a minimum.

Plate 5029 shows the combined water-tight switch and receptacle, both with the cover on and off. This is used in exposed places where a portable light is required, and a switch is needed. The cap, attached to the box by a chain, closes the box water-tight when the plug is removed.

Plate 5025 shows the same box and cover, but with a switch only. The same box is used for the receptacle only.

MOLDING.

All electric-light wires on our vessels are inclosed in wooden molding. Each wire is in a groove by itself, and is separated from all other wires and from the ship by at least one-half inch of wood. The molding is a mechanical protection to the wires, and also prevents grounds or short circuits even if the insulation of the wires should be injured.

The style of molding that has grown up in our vessels has become so large that it was thought best to try to reduce it. Consequently, a specification has just been issued, in which the size, weight, and cost have been materially reduced, without taking away any of the efficiency of the old style.

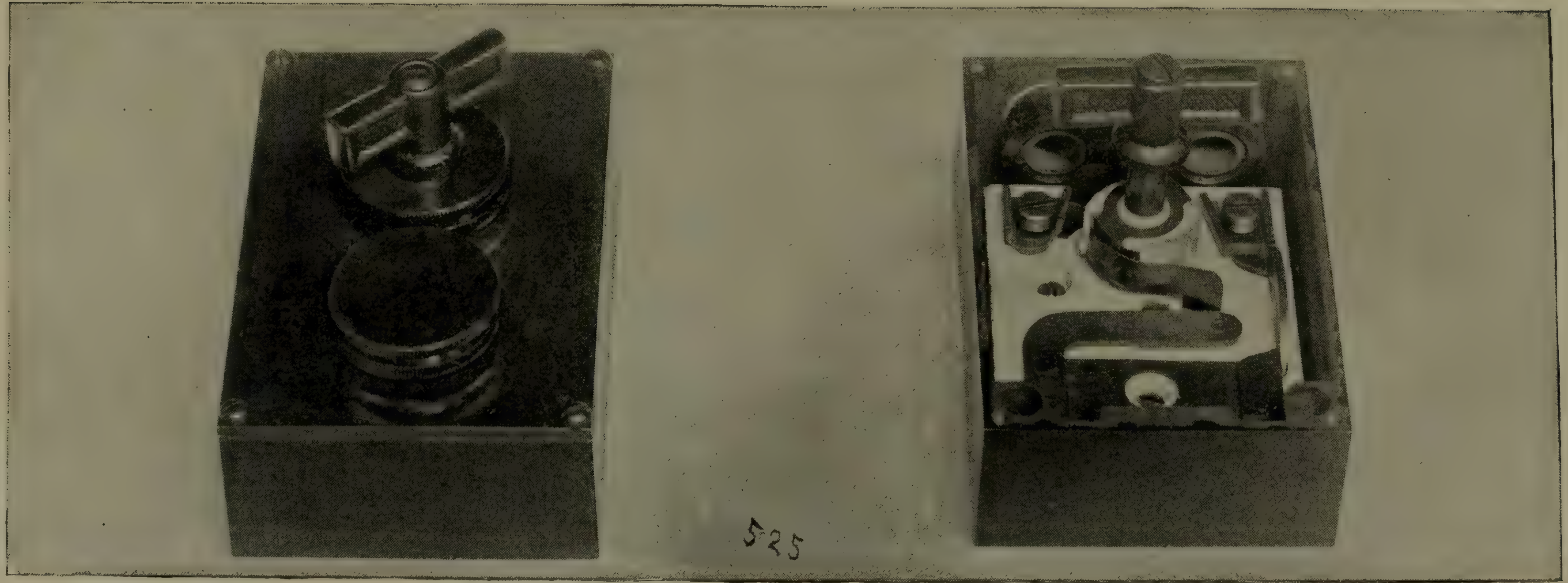
A new feature that has been introduced in these specifications is the use of a "backing strip." This is a strip of wood as wide as the molding proper and thick enough to cover all bolt heads, flanges, etc., in the path of the molding. This is secured in place to the vessel, and forms a bed for the molding proper, and also for the junction boxes from which the branches are taken off. Where there are no bolt heads, etc., but a smooth bulkhead to be run over, the backing strip is omitted. The advantages of this plan are—

(1) Decrease in cost of molding, as the backing strip and the molding can both be manufactured more cheaply than solid molding of the same total thickness.

(2) Uniformity.

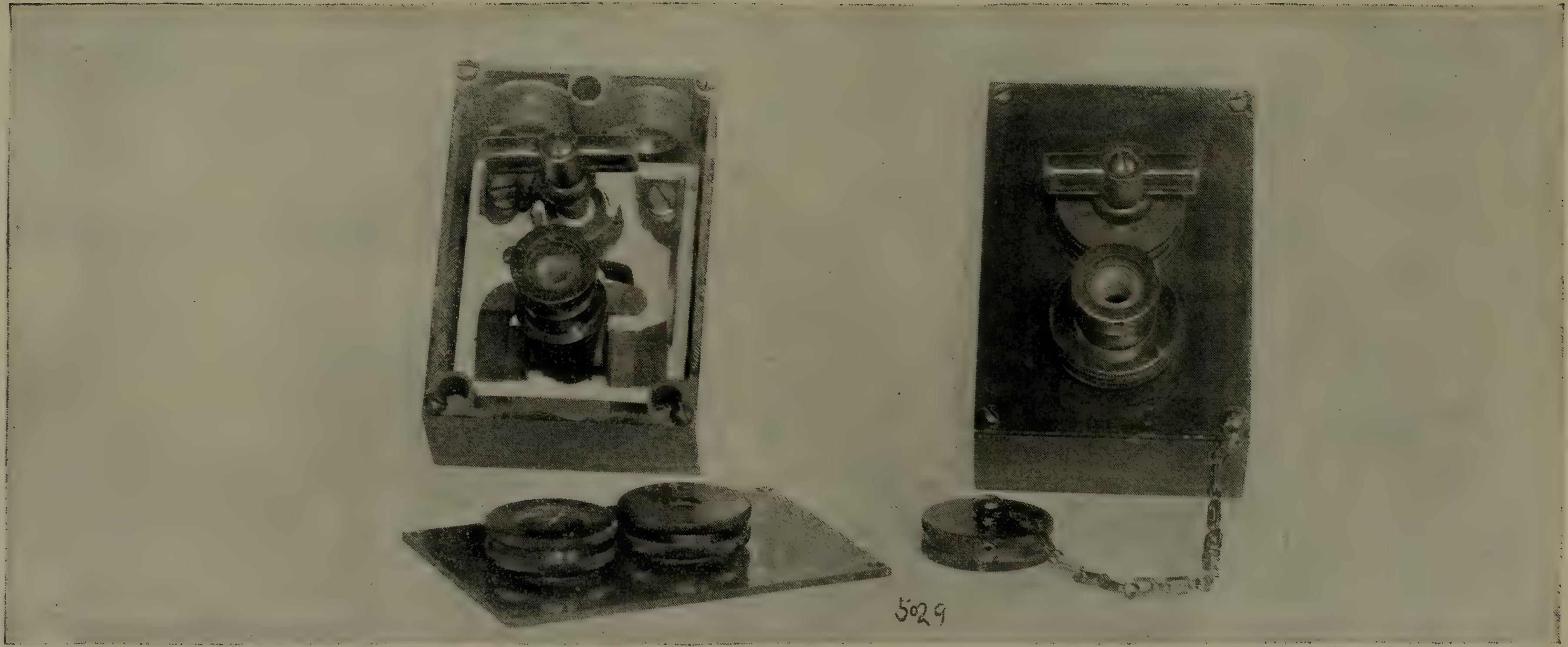
(3) Greater convenience in doing the work of wiring, as the backing strip can be secured in place before it would be advisable to secure the molding proper.

A and A_1 are designs of molding for sizes of wire between 63916 circular mils and 124468 circular mils; A is shown with backing strip and A_1 as solid. B and B_1 are for all sizes of wire from 63916 circular mils down to branch wire. C and C_1 are for branch wires, No. 16, B. W. G.

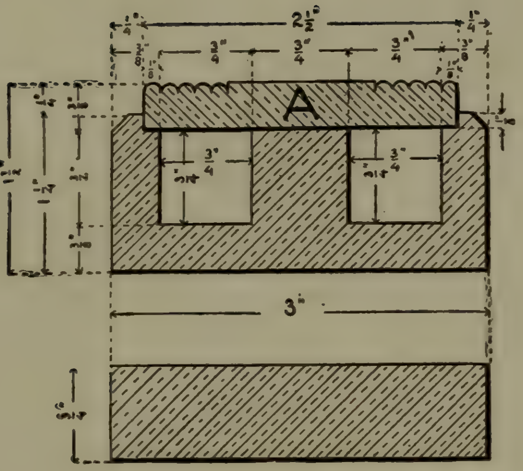


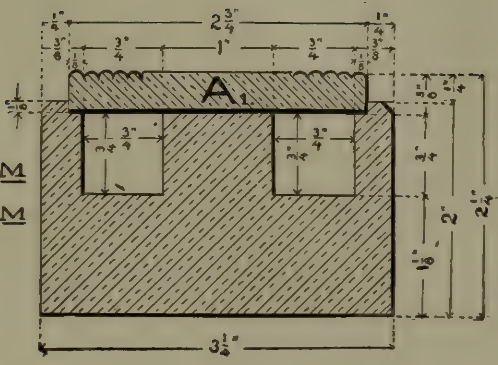
525

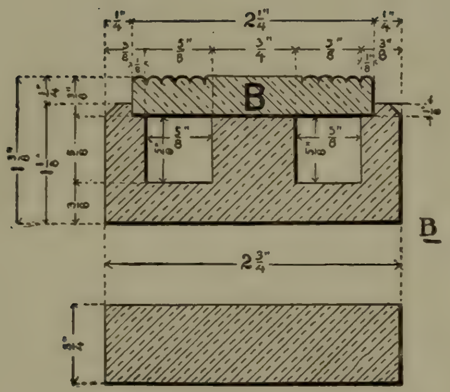
Water-tight Switch.

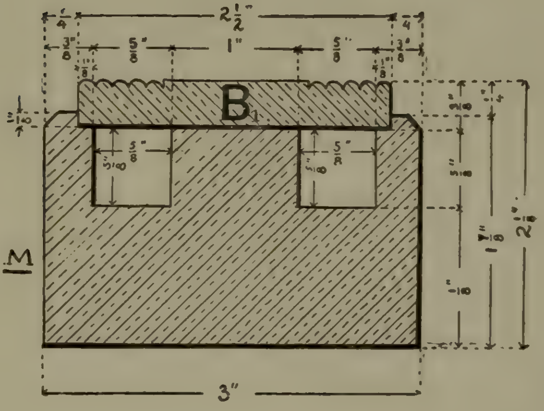


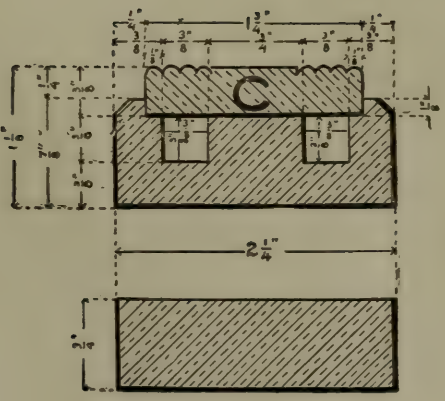
Combined Water-tight Switch and Receptacle.

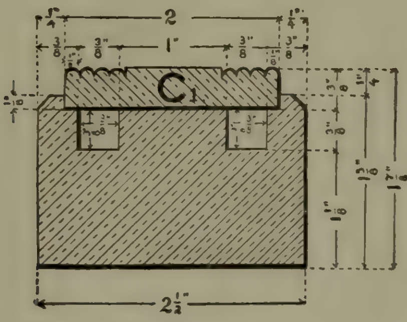

A
2½"
¼"
3/4"
3"
1½"
1¼"
3/4"


A₁
2¾"
1"
3/4"
M
M
2"
2¼"
3½"

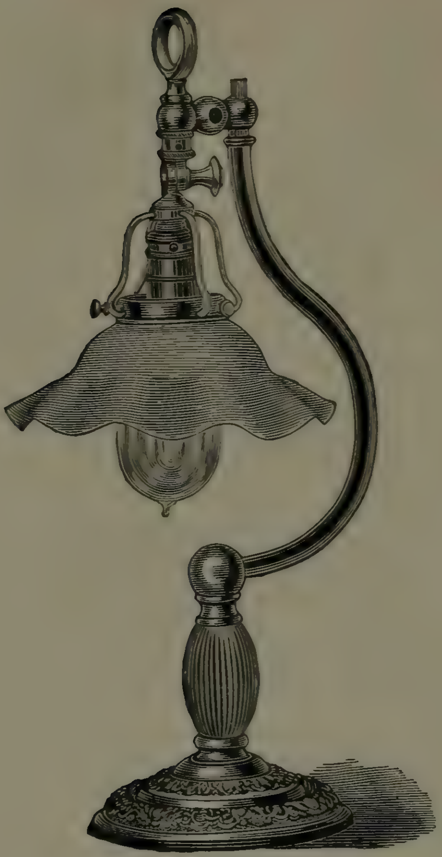

B
2¼"
3/4"
5/8"
1⅛"
2¾"
B
3/4"


B₁
2½"
1"
5/8"
M
1⅞"
2⅛"
3"

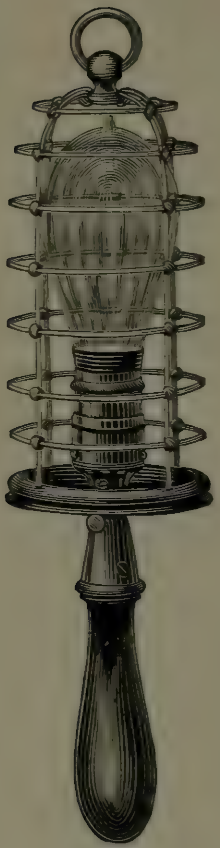

C
1¾"
1⅛"
⅞"
2¼"


C₁
2
1"
3/8"
2¼"

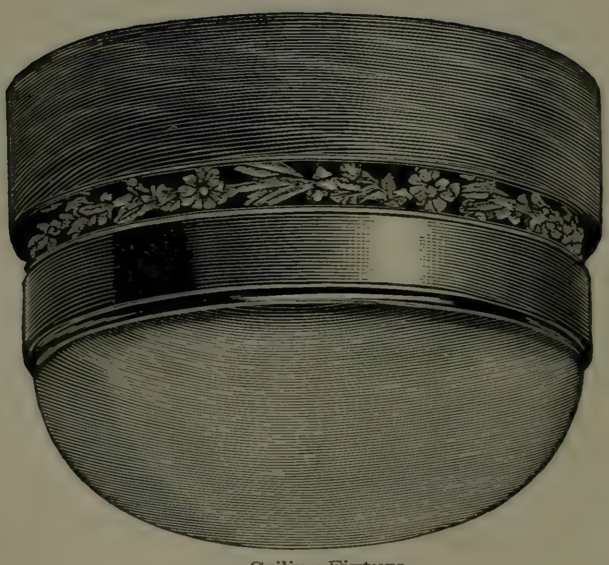
A



Desk Light.

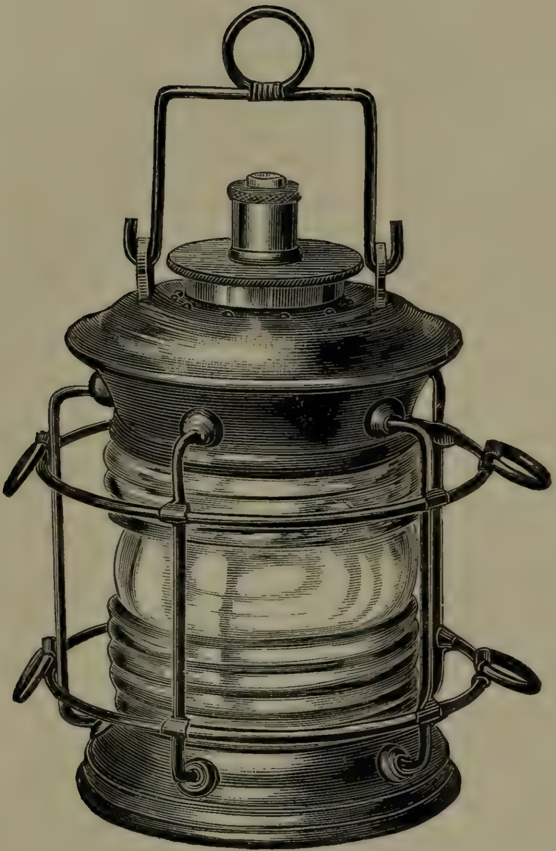


Portable.

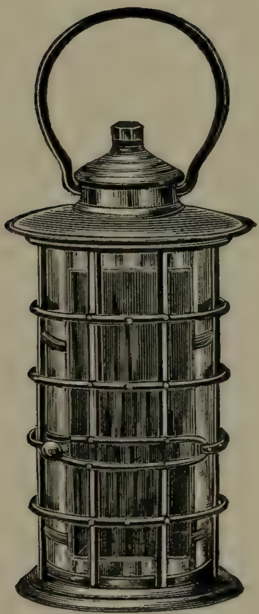


Ceiling Fixture.

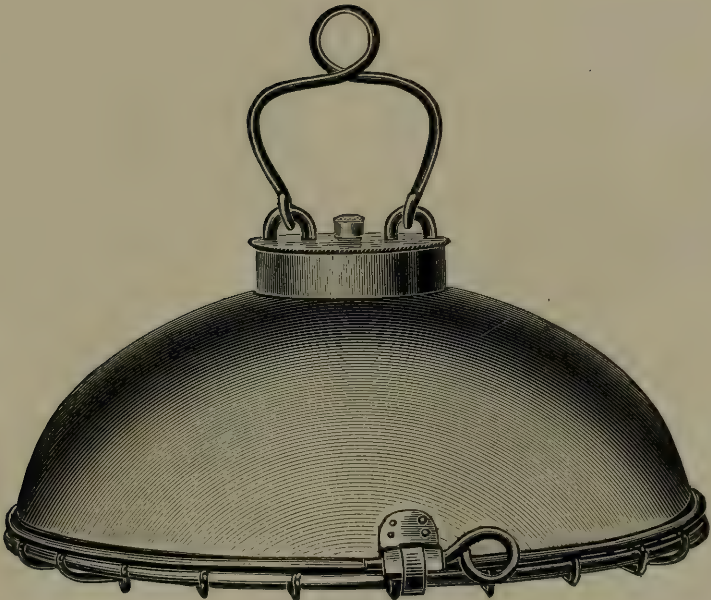
B



Single Signal Lantern.

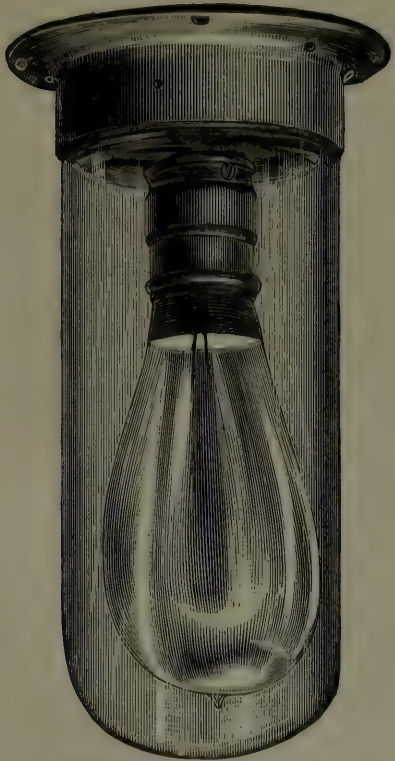


Battle Lantern.

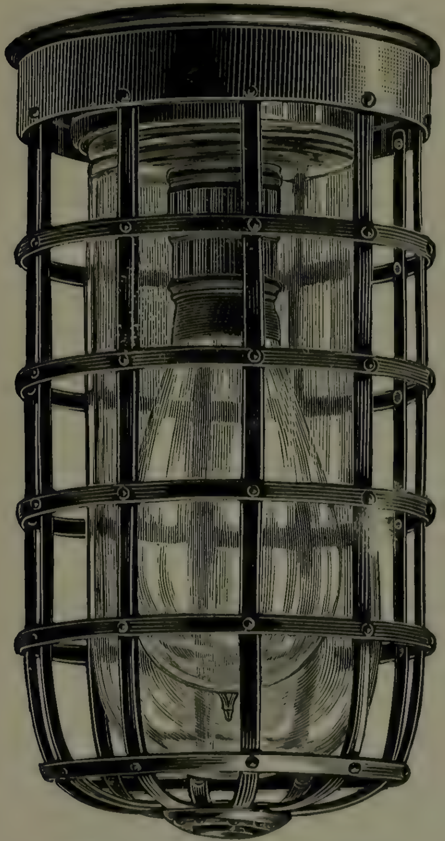


Cargo Reflector.

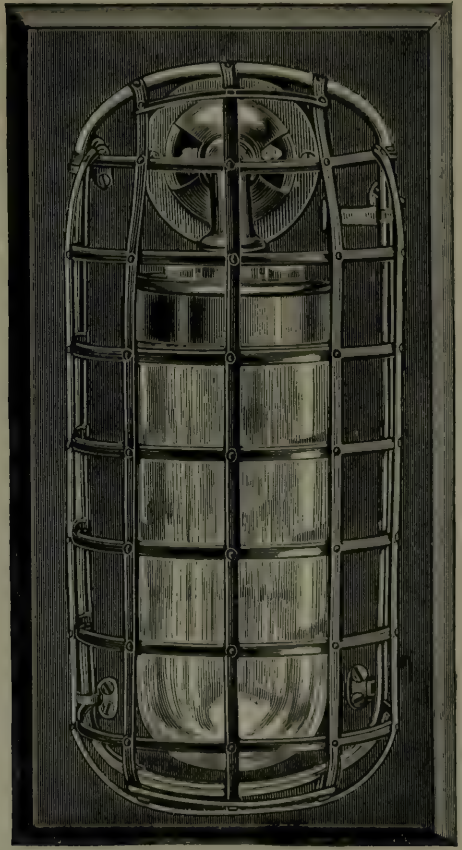
C



Steam-tight Globe Fixture.



Steam-tight Globe. With Guard.



Bulkhead Fixture.

FIXTURES.

Standard fixtures have at last been adopted and manufactured. They are on the same general lines as the most successful experimental fixtures heretofore used, but the number of varieties has been reduced, and the parts of similar fixtures made interchangeable when possible. The material of which they are made is bronze, and a dead-black finish is given them. In these standard fixtures the strength and water-tightness have been increased and the weight and cost reduced.

The accompanying cuts show the principal standard fixtures.

The desk light is used in officers' rooms and offices. The portion of the fixture which carries the lamp and shade can be lifted from the standard and carried to any part of the room or suspended overhead by the ring.

The portable is used for fire rooms, store rooms, etc. It is wired through the handle, the wire being stopped back to prevent too short a nip.

The ceiling fixture is used for overhead lighting in officers' quarters and in berthing spaces. This fixture is water-tight.

The steam tight globe fixture is used for overhead lighting, principally in engine and fire rooms. Where exposed to rough usage, the wire guard is added.

The bulkhead fixture is used where standing lights are required, principally in fire and engine rooms, and in berthing spaces. The ring which carries the lamp and globe is identical with that used on the steam tight globe fixture and on the battle lantern.

The battle lantern, also used without the shield as a deck lantern, is used principally on the upper deck and near the battery.

The single signal lantern is used for squadron lights, anchor light, etc. A double lantern is now being introduced for signaling messages.

The cargo reflector is a hollow spherical cap of copper, painted with white enamel paint on the inside, and arranged for four 16 c. p. lamps. It is used for night work, such as coaling or taking in stores.

Other fixtures, not shown in the cuts, are the lanterns for side and mast head lights, and magazine lanterns; also brackets of the usual commercial type, for use in officers' quarters.

Combination fixtures, those arranged for using either oil or electric lights, have not usually been furnished to our vessels. The importance is recognized of providing and keeping in place, at all times, oil lamps or candles for use when the electric lights, for any cause whatever, can not be used. This contingency may arise at any time, and may be caused by the failure of the electric plant, by injury to its steam supply, or by injury to the mains; or it may be necessary, in order to economize coal, to stop running the dynamos for a considerable length of time.

Oil lights are supplied to our vessels to some extent, but they should be supplied for every compartment used in action, and should always be kept in place ready for use.

INCANDESCENT LAMPS.

All incandescent lamps now issued in our service are fitted with a uniform base, and the standard socket is designed to secure elasticity and to prevent the lamp from being shaken out. All lamps use 4 watts per candle power, within narrow limits, this low "efficiency" having proved to be the most economical practice for ship work. All lamps are made for 80 volts when giving their rated candle power (mean horizontal), and a variation from 78 to 81 volts is allowed. All lamps are marked with the actual voltage necessary to give their rated candle power, so that the 78-volt lamps can be used where the drop is greatest, and those requiring higher voltage are placed near the dynamos. As the drop on board our vessels is never more than 3 per cent at full load, and not more than 2 per cent, or 1.6 volts, at ordinary loads, this variation corresponds to that allowed in the voltage of the lamps.

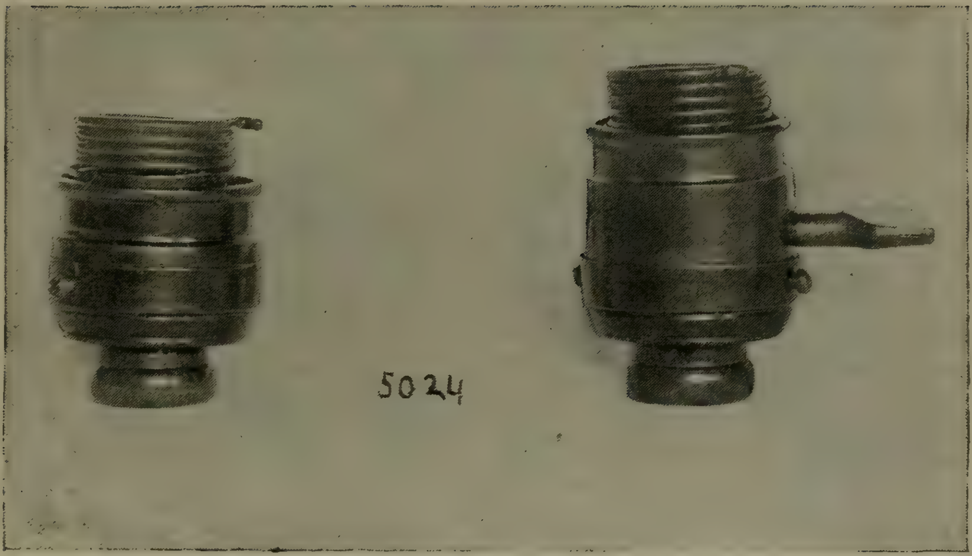
The single horseshoe filament is still in general use, though some spiral filaments have been experimented with for use in signal and other lanterns where a lens is used. It is found, however, that the spiral filament lamps have to be very accurately focused, or a large loss of light results. On the whole, the horseshoe filament seems to give better and more uniform results and will probably be used for all purposes. Multiple filament lamps have so far met with little favor.

The usual practice in regard to the candle power of lamps installed has been to use 16-candle-power lamps in all places except for storerooms and some of the battle lanterns, where 10-candle-power lamps are used, and for signals and running lights, where 32-candle-power lamps are used. But, in some recent installations 16-candle-power lamps have been used throughout, except for signal lanterns, where 32-candle-power lamps are considered necessary.

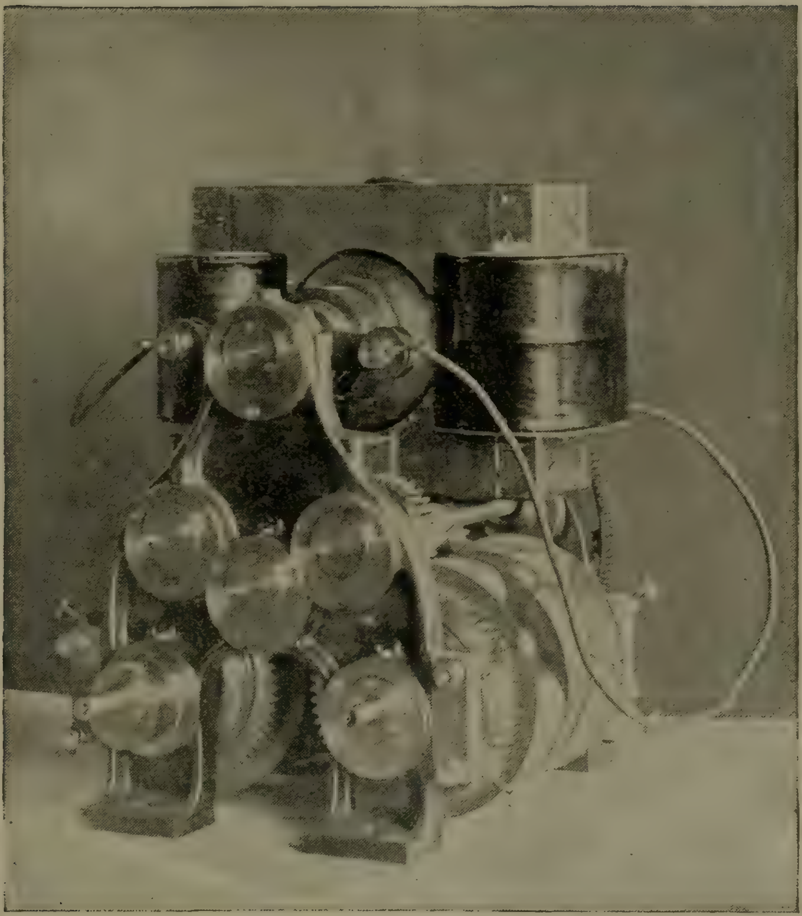
SEARCH LIGHTS.

The best practice as to the size, number, and location of search-light projectors are problems which have yet to be definitely solved, and so far are merely matters of conjecture. In some foreign navies, the practice is to have a large number of small search lights, so arranged as to produce a zone of light all around the vessel. In others, a small number of large lights are used, frequently arranged to be controlled in their movements from a distance. Both plans are supported by good reasons, but the latter finds more favor in our service, on account of the difficulty in finding locations for a large number, and the extra weight and cost of the first plan.

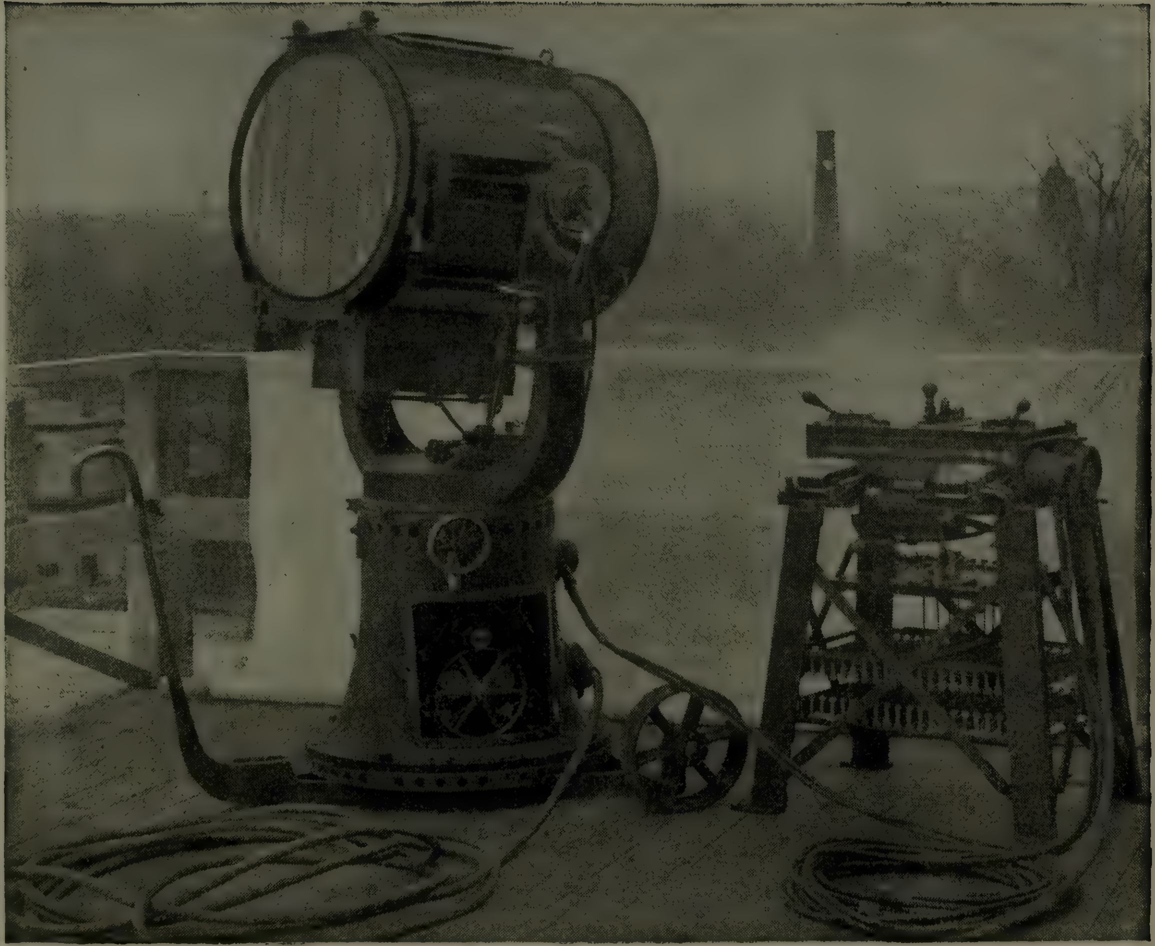
The location of search lights is a difficult problem. A location near the water line, which has been advocated as the best for utilizing the beam of light, is impracticable, as the light could only be used in perfectly smooth water. Consequently the lights have to be placed high enough to overcome this objection, and then the difficulty of getting out of the way of the secondary battery and of the blast of the large



Key and Keyless Sockets, Navy Standard.



CONTROLLING MECHANISM FOR SEARCH-LIGHT PROJECTOR.



Electrically Controlled Search-light Projector.

guns is presented. As a consequence, the number, size, and location of the lights have to be determined for each vessel, though general rules for different types have been formulated. On some vessels the projectors have had to be located on the masts, and these are necessarily controlled from a distance.

The sizes of the projectors used in our service are 30, 40, 60, and 75 centimeters in diameter. These take respectively 25, 40, 80, and 100 ampères current. The 30, 40, and 60 centimeter projectors are usually run at from 45 to 50 volts, but the 75-centimeter projector requires a greater voltage for the best results. All of these lamps are run from the same dynamos that supply the incandescent lamps, the voltage being reduced by a dead resistance, proportioned for the best working of the lamp. The use of a higher voltage at the dynamo than necessary for the lamp, the difference being taken up by dead resistance, is absolutely necessary when using large currents. The dead resistance is needed to steady the current and to prevent short circuits in working the lamp. The practice of reducing the voltage of the dynamo to nearly that required for the lamp, which was advocated some years ago in the interest of efficiency, has been abandoned.

Electrically controlled projectors, first designed at the torpedo station in Newport, and first brought out successfully in France, are now being introduced extensively in our own service and abroad. By this arrangement the elevation and training of the beam of light is under the control of the operator stationed at the most convenient place on the vessel. This is accomplished by a motor placed in the pedestal of the projector and geared to the barrel, the operating switches being located at the place selected, and at a distance from the projector. The cut of the controlling mechanism given shows the general view of one type of motor for this purpose, a brief description of which is as follows:

A single series motor trains and elevates the projector. The armature of this motor revolves always in the same direction, and is started or stopped by means of a switch on the controlling board. The speed of the armature is regulated by means of a rheostat in a circuit through the armature of the motor, allowing the armature current to be varied. Geared to the armature of the motor are four revolving electro-magnets, two on each side, the two on the same side being on the same spindle. One pair of magnets is for elevating or depressing the projector, the other pair for training. Between each pair of magnets is a disk of soft iron secured to a shaft, which, in turn, operates gearing which is connected by rods to gearing wheels on the projector. This disk is not in motion unless one or the other of its electro-magnets is excited; when this is done, however, the disk is attracted to the excited magnet, and a slot on the disk engages with a pin on the magnet frame, compelling the disk to revolve with the magnet and giving the motion through the gearing to the projector.

All the switches for operating this mechanism are on the controlling board, which can be located anywhere and connected to the motor by means of a multiple cable.

A new feature just added to this class of projector in our service is an automatic sweeping movement of the projector, through any desired angle, in any direction. This is accomplished by two movable dogs, secured by set screws to the circular base of the projector arms, and capable of being moved to any desired position. These dogs operate a reversing switch in the circuit of the training electro-magnets, which causes the projector to move automatically backward and forward over the arc included between the dogs.

The advantages to be gained by an electrically controlled projector are: 1. Concentration of control and attendance. 2. The projectors can be located in inaccessible places, as on a mast. 3. The visibility of objects is much greater to the operator when he is stationed some distance away from the projector and to one side.

The disadvantages are: 1. Increased complication. 2. Increased weight and space required. 3. The uncertain action of the automatic lamp for large currents.

The success of the electrically controlled projector depends almost entirely on first obtaining a reliable and satisfactory automatic lamp. This very desirable piece of apparatus has long been sought, the efforts, in most cases, being to convert the inclined carbon type of hand lamp into an automatic lamp. This has in a measure proved successful, and if the arc is not lengthened beyond 46–50 volts, and the current is kept below 60 amperes, the best of these lamps give excellent results if the carbons are good. But an attempt to increase the current brings in new difficulties. In general, the voltage of the arc and the size of the carbons must be increased, and the quality of the carbons must be of the very best. Even with every precaution, the unavoidable impurities in the carbons may start a roaring flame and shifting crater, or the carbons, being out of line a little, may overlap and short circuit. No one is supposed to be near the lamp to see what the matter is, or to make any necessary adjustments. The operator can see from the beam of light that something is wrong, but he has little chance to remedy it, except by sending some one to the lamp.

There has been developed in Germany an automatic lamp with horizontal carbons, the carbons being in the axis of the projector, and directly in line with each other. The crater is in the focus of the mirror and turned full toward it; the negative carbon is so small that little light is cut off. Very long arcs and large currents are used with this lamp. In a 110-centimeter projector the ordinary current is 150 ampères, with a difference of potential in the arc of 60 volts. At the Frankfort Exhibition there was exhibited a projector of 150 centimeters diameter, using a horizontal carbon automatic lamp, with a current of 150 ampères and 64 volts difference of potential of the arc. The positive carbon was 38 millimeters in diameter, and the negative, 26 millimeters. The normal length of the arc was 18 millimeters. The light from the projector was perfectly white and very steady. In a 90-centimeter projector, made in Germany for the English Government, the current used is 250 ampères.

No such results as these have been obtained with any other type of automatic lamp, and it is doubtful whether the inclined carbon lamp, used so extensively, can ever be made to give such results. When the latter type is used as a hand lamp, the control is better with large currents, but, even then, it is difficult and requires nice handling. Experiments with the horizontal carbon lamps are now in progress, and the results will largely shape future designs of naval projectors for our service.

In working arc lamps in parallel, as is done on board ship with search lights, it is necessary to have a certain amount of resistance in series with the arc. The amount of this resistance varies with the current used, and is especially important when using large currents. The practice in our service is to run the search lights direct from the dynamos, with a difference of potential of 80 volts at the dynamo terminals.

In this connection attention should be called to the quantities which can be varied to get certain desired results with a search light.

Taking a dynamo, with 80 volts difference of potential at the brushes, from which the arc lamp in question is to be run, the difference of potential of the arc and the current through the lamp may be varied as follows:

1. The difference of potential of the arc increases within limits with the length of the arc; and if the difference of potential at the lamp terminals is fixed, then the current depends mainly on the length of the arc, other things being equal.

2. If a certain length of arc, or in other words a certain working difference of potential is decided on, then the current through the lamp can be varied by changing the resistance of the circuit, *i. e.*, by varying the dead resistance in the circuit leading from the dynamo.

3. If a certain current is decided on it can be obtained by varying either the length of the arc, or by varying the dead resistance, or both.

4. If both length of arc and current are fixed, the arc is regulated to give the desired difference of potential, and the dead resistance varied to give the desired current, both being adjusted until the desired results are obtained. There should always be enough dead resistance left in the circuit to the dynamo to cause steady working, and to prevent danger from a short circuit. In the German navy this resistance is proportioned to give at least 7 volts drop.

In actual practice with automatic lamps on board ship one of two of these methods is available:

1. The difference of potential of the arc is fixed by adjusting permanently the tension of the spring opposing the action of the feeding magnets, and a fixed dead resistance (in the circuit of the dynamo),

located in the dynamo room, is properly proportioned to give the desired current.

2. The difference of potential of the arc being fixed, as above, the dead resistance to be variable and located on deck at the operating station, together with volt and ampère meters.

By the first method the automatic lamp is left entirely to itself, and the results must depend on the excellence of the lamp. By the second method the operator can control the current through the lamp, and can remedy some of the defects of operation.

If electrically controlled projectors are to be a practical success, an automatic lamp must be obtained which can take care of itself without any assistance whatever from the operator.

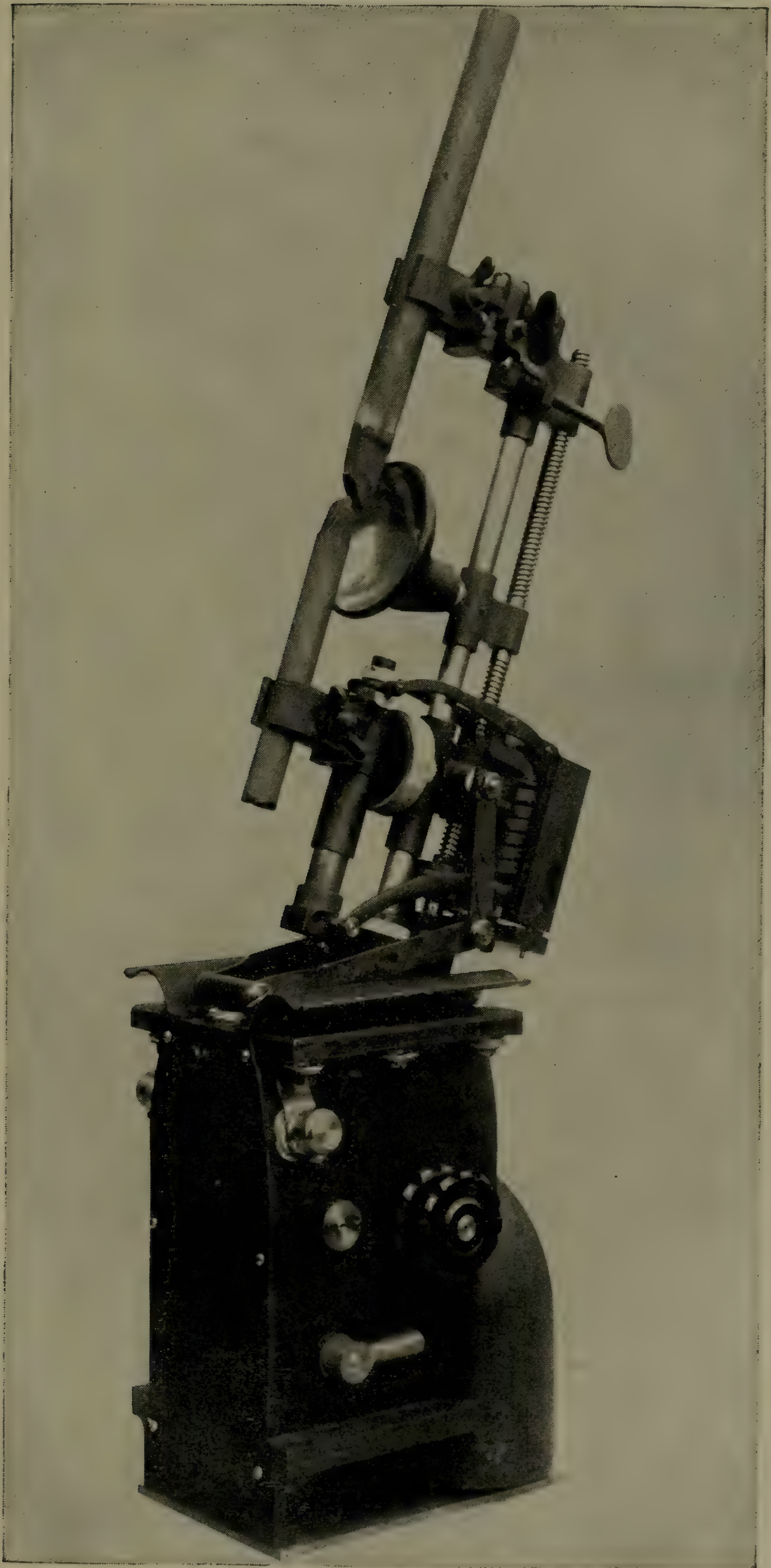
Referring to the accompanying cut of the automatic lamp, which is of the latest type in use in our service, a brief description of its working will be given.

The general style of the lamp is the same as that of the hand lamp of in use in our service for many years. The lamp is made automatic in feeding by means of two magnets, one located in the rear of the base of the lamp, which, by means of a make-and-break attachment, operates a pawl, which feeds the carbons together by gearing. This magnet is in shunt with the main current through the lamp; its mechanism is inclosed in the base of the lamp and can not be seen in detail in the cut.

Just back of the screw which feeds the carbons, is seen the series magnet, which is energized as soon as the current passes through the lamp, and draws the lower carbon down, thus striking and maintaining the arc.

The operation of both of these magnets is opposed by spiral springs, thus regulating the amount of pull necessary to operate the mechanism of each. With the shunt magnet, this pull depends on the difference of potential at the magnet, or, what is the same thing, the difference of potential of the arc. By altering the tension of the spring the length of arc can be altered. The pull on the series magnet depends on the amount of current passing through it, and consequently through the lamp. The tension of this spring fixes the smallest current which will strike and maintain the arc.

To operate the lamp, the carbons being separated, close the switch in the lamp circuit. This is located on the projector base and on the control board, if one is used. As soon as this is done the current passes through the shunt magnet, and by means of a make-and-break attachment, operates the pawl which feeds the carbons together. As soon as the carbons touch each other, the main current flows through the carbons and the coils of the series magnet, energizing the latter and striking the arc. The difference of potential at the terminals of the shunt magnet is now so slight that sufficient current does not flow through its coils to attract the armature against the tension of the opposing spring. As



Lamp for Search-light. Hand or Automatic.

the carbons waste and the arc grows longer, this difference of potential increases until the tension of the spring is overcome and the magnet feeds the carbons toward each other. No provision is made for reëstablishing the normal length of the arc when it has become too short, except the natural waste of the carbons.

In this connection it should be stated that the carbons should always be "formed" by hand before the lamp is used automatically.

The manufacture of search lights in this country has lately been taken up in earnest, and with a good prospect of excellent results.

ELECTRIC NIGHT SIGNALS.

The advantages to be gained by the use of the electric light for night signals were recognized as soon as this light was introduced on board war vessels, and experiments have been continuous to determine the best method to be used. The first experiments of this nature were made on the U. S. S. *Trenton*, shortly after her electric plant was installed, in September, 1883. This first electrical signaling apparatus consisted of two clear incandescent lamps suspended aloft some distance apart, and two make-and-break keys. Signals were sent by the Myer code very satisfactorily, and with reasonable speed.

Since that time, numerous devices and systems have been tried, both in this country and abroad. The general aim of one class of experiments has been to obtain a good, quick, and reliable method of telegraphing by single characters; and of another, to obtain an efficient system of tactical and general signals, including the telegraphic code.

The attempt has been made abroad to signal by the Morse code, by means of a single high-powered (50-candle-power) incandescent lamp placed on the masthead, but so far the efforts have not met with much success. Various devices have been used, among them an electro-magnetic shutter which can be operated from deck, disclosing and shielding the light at will; the connection of the lamp to a key on deck, by which the current can be made or broken; the use of a bag which could be raised from or lowered over the lamp by means of a halliard from deck. None of these plans has proved successful. The first failed on account of the complex design of the shutter, and its liability to get out of order. The second was not successful because the time necessary for the filament of the lamp to heat to incandescence, and to cool below it, is quite appreciable, making speed impossible. Multiple filament lamps have been used to get over this difficulty, but with only fair results. The third method appears to be the best, but this is not entirely satisfactory.

In the second series of experiments a number of lanterns fitted with incandescent lamps, which could be lighted or extinguished at will, have generally been used. In one proposed system ten white lanterns were used. Only numeral signals could be made with this apparatus with any rapidity, and telegraphing could only be done by using a few of the lights in the same manner as the two were used on the *Trenton*. The system was designed principally for general signals, and the use of the signal book would always be necessary. Experiments with lanterns are still in progress, but some general conclusions seem to have been reached. It seems to be generally conceded that some number of double lanterns should be used, and that each double lantern should show one red and one white light, or a flashing white and a steady white light. After much investigation four double lanterns seems to be the number most generally favored as giving enough combinations to allow the use of any code, international, general, telegraphic, tactical, etc., and at the same time to require no more room for hoist than can ordinarily be found on even small vessels; and, most important, the combinations are not too numerous to be memorized.

The question of a suitable keyboard is one that has not yet been satisfactorily settled. The requirements, in general, for such a board are—

(1) It should not be bulky and should be water-tight.

(2) It should be designed for any combination of the red and white lights, taken 1, 2, 3, and 4 at a time, never using the two lights in the same lantern at the same time.

(3) To make a given combination, one movement is preferable, as the setting of an arm, and in any event the number of motions should be as few as possible.

(4) The make-and-break switch should preferably be in the common return, contact with the various terminals being made when the current is broken. Spring contacts are undesirable on account of the weakening of the spring.

A keyboard has just been designed which combines all these characteristics, though not yet tested.

The lantern is, as above stated, usually a double one, and is suspended from a jackstay especially fitted for it. The use of Fresnel lenses in these lanterns is not universal, though the range of signaling is increased by their use. If lenses are used, the lantern should be freely suspended, so that the rays of light are thrown out horizontally at all times, regardless of the motion of the vessel But, if lanterns with plain glasses are used, it is preferable to secure the lantern at both ends to prevent swinging, as connections are then less liable to be broken. The lanterns should be water-tight and should show the light all around; this last is most important and prevents the use of reflectors to increase the amount of light in any given direction. They should also be practically air-tight, to prevent the access of powder smoke from the guns to the inside of the lanterns, which corrodes the connections and clouds the glass. Great care is necessary in making the connections from the cable to each lamp, especially when lenses are used, to prevent breaking the connections, and they should be made so that no strain will ever come on them.

The installations of the lanterns should be practically permanent, and in such a location that the all-around view is least obstructed. It should not be necessary to lower the system of lanterns for the purpose of renewing lamps, and when once in place the lanterns should not be lowered, except during the daytime for repairs, and then as seldom as possible.

The method of suspension for the lanterns, adopted by the Department for the apparatus now building, consists of two wire jackstays with connecting cross-arms from the centers of which the lanterns hang, spaced 10 feet apart. The upper end of this double jackstay secures aloft to a gaff or stay, and the lower end sets up with two turn buckles, one on each leg, to prevent cable laying. The cable, containing a wire for each lamp with a common return, is seized to one leg of this jackstay; the lower ends of the lanterns can be prevented from swinging in bad weather by a distance line.

The principal keyboards so far used with this double-lantern system are the Kazolewski in Italy, the Sellner in Austria, an experimental board in France, the Ardois in Spain, and the Conz in Germany. The Massari keyboard is being experimented with in Italy, and the Ardois and Sellner in this country. In France is also used the De Meriteus keyboard, designed for use with eleven single lanterns. In England the double-lantern system does not seem to have met with great favor, the efforts there having been directed to obtaining some system of telegraphing with one light as already described.

In this country the double-lantern system meets with entire approval, but the need of a less complex code, and of a simple and reliable keyboard is felt. This system, using four double lanterns with a good keyboard, would seem to solve the problem of night signals for distances of 5 miles or less. For greater distances no successful electrical system, except possibly telegraphing with the search light, has yet been devised, nor is such a system necessary in view of the fact that we already have a most excellent nonelectric system (Very's) for the distant night signaling.

MOTORS.

The introduction of electric motors on board naval vessels has not been so rapid as might have been expected. This has been partly due to the fact that it has been hard to obtain motors suitable to the conditions under which they have to work on board ship, owing to the fact that the demand on shore for a different class of apparatus has almost entirely occupied the attention of manufacturers. This difficulty, together with the fact that the use of electric motors has been said to be uneconomical on board ship, has greatly retarded their introduction. But the many uses for which the electric motor is far superior to any other in efficiency, weight, cleanliness, convenience, and ease of repair, make it certain that it will be extensively introduced in the near future.

The question of the form of motive power to be used on board ship for auxiliary purposes, can not be settled in favor of one form to the exclusion of others. The great advantages of an electric motor over any other lie in the transmission of energy to it, the ease with which repairs to the leads can be made, and the readiness with which the motor can be controlled from a distance. In compartments near the boilers it is more economical to use steam engines, as a double conversion of energy and much weight is thus saved; but in more remote parts of the vessel, where the length of steam piping is much greater than that to the dynamo engines, the electric motor is more economical in every way.

In some parts of a vessel and for some purposes, the question of economy has to give way to other considerations. It may be very difficult to lead any kind of piping, either steam, hydraulic, or compressed air, to the place where power is wanted; or, if such pipes can be lead, they may be exposed to injury which would disable the machine and which could not be repaired. The advantage in using electric motors for these places is obvious.

The loss of power in gearing, so often complained of and said to be due to the unavoidably high speed of electric motors, is not at all confined to them. Slow-speed motors can be made, and the loss in gearing very much reduced. This loss in gearing is often intentional, and is introduced to get rid of the "kick" or "back lash" of the machine on stopping, when such action would be detrimental. The hydraulic system is the only one not open to this objection, and it is believed that the electric system could be freed from it by the use of a well-designed magnetic brake.

Another item that is generally charged against the introduction of electric motors is the weight of the dynamos and engines necessary to furnish the current to run them. If special generating sets have to be installed for this purpose, this charge would be just, but as there is always enough electric power furnished a vessel to work all incandescent lights on battle circuits and all search lights, at one time, together with a surplus in large vessels, it is apparent that in times of peace there is abundant electrical energy available to supply all motors which would be used only at that time. And, for motors which would be used only in time of battle, the advantages of the electric motor for many purposes would offset any increase in weight, especially since this increase would be trifling when the weight of hydraulic or air pumps, and of steam, hydraulic, or air pipes, are taken into account.

In some foreign vessels the electric motor has been extensively introduced, even in places where steam would have been more economical and perhaps better in every respect. This form of motor can not take the place of all other forms, either on board ship or on shore, and it should not be used except for purposes for which it is well adapted and superior to other types.

In our service the only uses to which electric motors have been put so far are (1) for ventilating fans; (2) rapid-fire guns; (3) ammunition hoists; (4) training guns (experimental); (5) operating valve of steering engine.

It could be further used to advantage for (1) all hoists on deck; (2) torpedo discharging apparatus; (3) steering; (4) ash hoists; (5) workshop machinery.

The type of motor to be used should be selected with reference to the nature of the work to be performed. In general, a shunt wound motor is best adapted for service when nearly constant speed with varying loads is required. A starting box is necessary with this type of motor, and it should never be overloaded to any extent, nor should it be run at less than its rated speed.

A series wound motor is best suited for use where constant speed is not required, or where there is danger of overloading. This motor does not require a starting rheostat.

A combination of these two types is found in the cumulative motor, which is used principally for freight hoists, etc. This motor maintains a fairly constant speed for all loads below a given amount, and will handle greater loads at a reduced speed.

Whatever form of motor is used should be designed for the conditions on board ship, and should be handled intelligently, if satisfactory results are desired.

MEANS OF INTERIOR COMMUNICATION.

This most important question has received considerable attention during the past year in our service, and an attempt is being made to simplify the system without sacrificing efficiency, and to obtain more reliable apparatus. While it is very essential that communication between various parts of the ship should be rapid and certain, the tendency has been to overdo it, and thereby create confusion rather than promote efficiency.

The various means of interior communication considered necessary on board ship consist in general of (1) voice pipes or telephones; (2) telegraphs for signaling revolutions, helm angles, ranges, etc.; (3) indicators for showing automatically the revolutions, helm angles, etc., at any instant; (4) call bells; (5) water and fire alarms; (6) general alarm gongs.

The places where these instruments are used may be grouped as (1) from fighting centers to machinery and compartments used in action, (2) from maneuvering centers to machinery and compartments used in ordinary cruising, and (3) from officers' quarters to various parts of the vessel for convenience in every-day life.

Considering first the various classes of instruments, efforts have been made to improve on the kinds now in use, and with considerable success. Voice pipes for long distances have been found unsatisfactory unless made of large diameter and led with few bends. To make them of sufficiently large diameter, when so many are necessary, would be impracticable in most places and impossible in some. Therefore, extensive experiments with the telephone have been made under conditions of actual service, extending over more than a year, and the results obtained leave no doubt as to the suitability of the telephone for use on board ship. It is superior to the voice pipe in weight, cost, space occupied, clearness of speech, ease of installation, and inferior only in that it can not stand such rough usage. Still it has been found that, with ordinary care, these instruments are reliable and do not give trouble. They are being installed extensively in ships now building, replacing voice tubes in many places.

The engine telegraph most generally used at present in all naval and merchant steamers is mechanical. This has given general satisfaction and is retained principally on account of the confidence felt in its reliability. Where the leads are long, however, and where sending instruments, which must indicate alike at all times, have to be located at several stations, the use of this form of instrument becomes difficult and often impracticable. An electrical telegraph which is reliable would be superior in every way to the mechanical form, and experiments are being made on this subject which have not yet been concluded.

For cruising in squadron, a telegraph more finely divided than the functional telegraph above alluded to, is necessary. "Stop," "Back," "Full speed," "Half speed," etc., do not allow of sufficiently small changes in speed to be made for squadron cruising, and consequently a revolution telegraph, by which the desired number of revolutions of the main engines can be signaled, has been required. Intimately connected with this instrument is the revolution indicator, which indicates automatically and continuously the number of revolutions per minute. The two instruments form a complete system and give accurate control of the speed of the vessel to the officer in charge on deck.

Helm telegraphs and indicators of the same general characters as those just mentioned are also installed. The vessel can thus be conned on deck to any steering station, which is very important in action or in case of accident.

Water and fire alarm systems are now required to be quite extensive, owing to the large number of compartments in a vessel and the number of water-tight bulkheads. The water alarms are operated by a float, which, on rising, operates a circuit-closer and rings the bell of an annunciator, located on deck. One of these circuit-closers is located in every water-tight compartment. The principal difficulty to be overcome is in keeping the connections of the circuit-closer from being corroded by the bilge water. This is in a measure prevented, by locating the circuit-closer some distance above the bilge, and in an accessible place, where it can be frequently examined and tested, connection being made to the float by means of a rod or lever.

A satisfactory thermostat for fire alarms is more difficult to find. The mercurial form, which acts on the principle of the thermometer and closes the circuit for any given temperature, is liable to give a false alarm on account of a "pumping action" when the vessel has much motion. A very good form, which is operated by the expansion of a spring, is objectionable on account of the sparking at the contact points when the circuit is made or broken, thus rendering an explosion liable. Whatever form is used must be sealed to prevent a possibility of this occurring.

It has been proposed to operate these alarms on a closed circuit, breaking the circuit, instead of making it, to give an alarm. This would cause the system to give an alarm whenever an accidental break should occur, thus making sure that the apparatus is in working order and simplifying inspection. Though possessing some merits, this plan has not yet been adopted in our service.

In regard to the location of these various instruments, the second grouping given above must be considered. The connection of the fighting centers to various parts of the vessel is naturally the most difficult to do satisfactorily. The whole theory of a modern war vessel is that, in time of battle, the whole vessel and every part of the vessel are under the direct control of the commanding officer. He must be able to control the engines, the helm, the guns, torpedoes, and all the various machinery by which the vessel moves and fights. At the same time he must watch attentively the movements of the enemy. The place from which he is supposed to do all this is usually an armored compartment of contracted dimensions and necessarily exposed.

These being the conditions, it is obvious (1) that the commanding officer must be in communication with a large number of places; (2) that this communication must be as certain as it is possible to make it; (3) that it is absolutely impossible that he should personally handle the instruments in giving his orders; (4) that it is impossible to have more than one assistant at hand without overcrowding the compartment.

These considerations have led to the adoption, in late vessels, of a central station for signals, situated so that the commanding officer can give his orders and have them transmitted, without taking his attention from the scene of action, and so protected that the liability of injury to the instruments and means of communication is as small as possible.

CONCLUSION.

In the preparation of this paper the records of the Bureau of Equipment have been consulted, and valuable assistance has been given by Commander J. S. Newell, U. S. Navy, Naval Inspector of Electric Lighting, and by Lieut. J. B. Murdock, U. S. Navy. All information as to the practice in foreign navies has been obtained from a report of Lieutenant Murdock to the Bureau of Equipment.

The various cuts with which this article is illustrated were made from photographs, drawings, and electrotypes kindly furnished by the Edison and the Schuyler Electric Companies, by the Waddell-Entz Motor Co., and by Page Bros. & Co.

VI.

THE NAVAL MANŒUVRES OF 1891.

By Lieut. Charles C. Rogers, U. S. Navy.

Much of the following narrative is based upon press dispatches, as few official reports of the manœuvres have reached the public.

ENGLAND.

The following general programme of the 1891 manœuvres was issued by the Admiralty:

GENERAL ORDERS.

(1) The Lords Commissioners of the Admiralty have decided to take advantage of the partial mobilization of the fleet when completed to carry out two distinct sets of manœuvres.

Of these the principal will have a tactical character and will consist of a series of exercises to be performed by two independent fleets. The secondary will consist of operations in the St. George's Channel, to be undertaken by two squadrons opposed to each other, one of which will comprise a number of torpedo boats.

(2) The ships, etc., assigned to the Northern Fleet will assemble first in the Downs.

(3) The ships, etc., assigned to the Western Fleet will assemble first at Portland.

(4) The ships, etc., assigned to the Red Squadron will assemble first at Torbay.

(5) The ships, torpedo boats, etc., assigned to the Blue Squadron will first assemble at Falmouth.

(6) The *Belleisle* will proceed to Kingstown, if not already there. After completing her crew she may put to sea to carry out any exercises which may be due, her proceedings being so arranged that she will be back at Kingstown not later than the date at which the remainder of the Blue Squadron reach their ports.

(7) Mobilized and newly commissioned ships, not coming from Portsmouth, are to proceed direct to the places of assembly without calling at Spithead.

(8) Torpedo boats are to proceed to the place of assembly, as most convenient, and with as little delay as possible.

SECTION II.

INTRODUCTORY CRUISE.

(1) When in all respects ready, the Northern and Western Fleets are to put to sea for a period of exercise which may be extended to eight days, anchoring as frequently as may be convenient, so that the instructive evolutions of fleet anchoring and getting under way may be practiced.

(2) At the expiration of the introductory cruise the Northern Fleet will assemble in the Firth of Forth, and the Western Fleet at Berehaven to complete with coal.

(3) The introductory cruise of the Red and Blue Squadrons may be extended to seven days, during which period exercises either at sea or at an anchorage may be carried out at the discretion of the officer in command of such squadron.

SECTION III.

MANŒUVRE CRUISES AND OPERATIONS.

(1) Flag Officers in command of manœuvre Fleets will report by telegram to the Admiralty when their ships are complete with coal and ready for sea. On receipt of this report, each fleet will be directed by telegram to put to sea and practice the manœuvres ordered. It is expected that these exercises will be carried out on at least six days, and movements should be so arranged that ships of the Northern Fleet shall, after the manœuvres, have completed their target practice and shall reach Yarmouth Roads; and the ships of the Western Fleet shall also after the manœuvres have completed their target practice, and shall reach Torbay not later than the twelfth day from the beginning of the manœuvres proper.

(2) Weather permitting, the fleets are to anchor, and as soon as practicable after arrival at the anchorage the mobilized ships are to be inspected and sent back to their ports. Arrangements, as directed in Section VI, for the reception of assumed wounded in hospitals are to be made in the case of ships returning to the ports.

(3) The proceedings of the two squadrons which are to carry out manœuvres in St. George's Channel will be as follows: At the expiration of the introductory cruise the Red Squadron will put into Milford Haven to complete with coal, and the Blue Squadron into the several places on the western coast of the St. George's Channel which have been specially selected and at which the vessels and torpedo boats will take in coal as requisite. Officers commanding the squadrons are to report by telegram to the Admiralty when the ships, torpedo boats, etc., under their orders are ready for sea.

On receipt of this report the following telegram will be sent to each ship:

Manœuvres are to begin at ——— on the ——— and end at ——— on the ———.

NOTE.—The total time will be exactly eight days.

(4) As soon as practicable after the conclusion of the manœuvre period and the completion of target practice carried out when the manœuvres have ended, the Red Squadron is to repair to Milford Haven, where mobilized ships will be inspected and be dispatched to their ports, and the Blue Squadron is to repair to some convenient anchorage, on the Irish coast, for inspection of mobilized vessels and torpedo boats. After the inspection, the ships, boats, etc., are to be sent to their ports. Arrangements, as directed in Section VI, for the reception of assumed wounded in hospitals at the three naval ports in England are to be made in the case of ships returning to their ports. As regards Haulbowline, these arrangements will be carried out on the arrival of the *Triumph* at Queenstown after the manœuvres.

(5) Foreign coasts are not to be approached within 5 miles.

(6) Reports on manœuvres are to be confined to that subject, and should not include statements of defects or similar matters.

SECTION IV.

TARGET PRACTICE (TO BE CARRIED OUT AFTER THE MANŒUVRES).

(1) Only one-half of one quarter's allowance of ammunition is to be expended from the heavy, light, machine, and quick-firing guns of the mobilized ships, and this proportion is only to be fired at the termination of the manœuvres, when the guns' crews are accustomed to their work, so that it may be expended to the best advantage.

(2) Practice from aiming-rifles fitted to guns is, if possible, to be carried out before the guns themselves are actually fired, such aiming-rifle practice being carried out at sea, with the ships steaming past the target.

(3) Target practice from both aiming-rifles and from all natures of guns, is, in the case of mobilized ships, to be carried out separately, and not in squadron, ships, when separated for target practice, being allowed ample time for the careful performance of their practices.

SECTION V.

MEMORANDUM.—SIGNAL TO BE HOISTED BY A SHIP CONVEYING ADMIRALTY ORDERS DURING MANŒUVRES.

(1) Should the Admiralty desire to communicate with the fleets during the progress of hostilities, and their instructions be conveyed by a ship attached to either of the opposing fleets, or by any other ship, such ship is to display the signal A K H.

(2) It will thus be known that she is acting under Admiralty orders, or is about to deliver dispatches or telegrams, or to signal orders received from the Admiralty, and the respective Admirals and Senior Officers are to take the necessary steps to insure that the orders so communicated are acted on without delay. The ship conveying such orders

on meeting other vessels must exercise discretion as to communicating the nature of the orders they are intrusted with, should no instruction on the point be given to her commanding officer.

(3) If the commanding officer of one vessel sights another flying the signal A K H, he is at once to close her, so as to place himself at a convenient distance for communicating by signal, should it be necessary to do so.

Section VI.

(1) In order to ascertain what arrangements could be made at the home ports, at short notice for the landing—after a general action with the enemy—of a considerable number of wounded, requiring hospital treatment, to each ship and torpedo boat under orders to proceed to Portsmouth, Devonport, Queenstown, or the Medway, an assumed number of wounded officers and wounded men is to be assigned.

(2) Before the ships leave for the ports, officers in command of fleets and squadrons are to communicate to each Commander-in-Chief by telegram the aggregate number of assumed wounded that may be expected to reach his port.

(3) Each ship, etc., on arriving at her port, should immediately make known, by signal, the number of assumed wounded on board requiring hospital treatment. The numbers indicated should be actually ready for landing, under suitable medical precautions, as the Commander-in-Chief or Senior Officer at the port may direct.

(4) At the ports the necessary arrangements are to be made for landing the numbers indicated as though they were really wounded. No expense is to be specially incurred for this purpose.

(5) Where sufficient means of conveyance from the landing place to the hospital cannot be procured, without special expenditure of money, the transport of the assumed wounded from their ships to the landing place only, and the completion of arrangements for reception in hospital of the aggregate number signaled are to be considered sufficient.

(6) A report of the steps taken should be sent to the Admiralty.

For the principal manœuvres two fleets will be formed; and for the secondary, or St. George's Channel manœuvres, two squadrons, one of which will include a number of torpedo boats.

The designation, places of assembly, and probable composition of the fleets and squadrons are given below.

An asterisk prefixed to any craft's name indicates that she will be mobilized or specially commissioned.

FOR THE PRINCIPAL MANŒUVRES.

THE NORTHERN FLEET.

[Place of assembly: First, The Downs; Second, Firth of Forth.]

Ships.	Guns.	Tons.	H. P.	Speed.	Complement.
Battle ships:				*Knots.*	
Camperdown	10	10, 600	11, 500	16. 8	526
Anson	10	10, 600	11, 500	16. 8	524
Howe	10	10, 300	11, 509	16. 8	515
Rodney	10	10, 300	11, 500	15	514
Nile*	10	11, 940	12, 000	16	548
Sanspareil*	15	10, 470	14, 482	16	583
Conqueror*	6	6, 200	6, 000	15. 5	335
Hero*	6	6, 200	6, 000	13. 5	335
Armored cruisers:					
Aurora	12	5, 600	8, 500	18. 5	464
Immortalité	12	5, 600	8, 500	18. 5	467
Protected cruisers:					
Mersey*	12	4, 050	6, 000	16	317
Pallas*	8	2, 575	7, 317	19	200
Latona*	8	3, 400	9, 438	20	214
Medea*	6	2, 800	9, 000	20	216
Medusa*	6	2, 800	9, 000	20	216
Tartar*	6	1, 770	3, 500	17. 3	172
Unprotected cruisers:					
Iris*	13	3, 730	7, 330	16	280
Ruby	12	2, 120	1, 830	12. 3	262
Torpedo vessels:					
Speedwell	2	735	3, 584	19. 4	85
Salamander*	2	770	2, 600	18	85
Sheldrake*	2	770	2, 600	18	85

FOR THE PRINCIPAL MANŒUVRES—Continued.

THE WESTERN FLEET.

[Place of assembly: First, Portland; second, Berehaven.]

Ships.	Guns.	Tons.	H. P.	Speed.	Complement.
Battle ships:				*Knots.*	
Alexandra	18	9,490	8,000	14	674
Superb	22	9,170	8,500	13.5	620
Invincible	16	6,010	4,839	11.6	482
Iron Duke	14	6,010	3,520	10.5	485
Audacious	18	6,010	4,830	13.5	482
Neptune	6	9,310	8,000	12.3	505
Triumph	14	6,640	3,659	12.5	470
Swiftsure	18	6.910	3,015	12.5	470
Armored cruiser:					
Narcissus*	12	5,600	8,500	18.5	467
Protected cruisers:					
Thames*	12	4,050	5,700	15.8	325
Forth*	12	4,050	5,700	16	325
Partially protected cruisers:					
Barham*	6	1,830	3,500	17.5	160
Bellona*	6	1,830	3,500	17.5	160
Barrosa*	6	1,580	2,800	16.5	160
Blonde*	6	1,580	2,800	16.5	160
Calypso	16	2,770	3,720	11.9	315
Unprotected cruiser:					
Volage	12	3,080	4,530	13.1	355
Torpedo vessels:					
Sharpshooter*	2	770	3,010	16.5	85
Spanker*	2	770	3,800	19	85

FOR THE SECONDARY, OR ST. GEORGE'S CHANNEL, MANŒUVRES.

THE RED SQUADRON.

[Place of assembly: First, Torbay; second, Milford Haven.]

Ships.	Guns.	Tons.	H. P.	Speed.	Complement.
Armored coast-defense vessel:				*Knots.*	
Hotspur	4	4,010	3,060	10.5	233
Armored cruisers:					
Shannon	9	5,390	3,370	10.5	448
Northampton	12	7,630	6,070	11.2	568
Partially protected cruiser:					
Barracouta*	6	1,580	2,200	16	160
Torpedo vessels:					
Seagull	2	770	3,033	19.9	85
Spider*	1	525	3,000	17.3	63
Skipjack*	2	770	3,500	19.1	85
Gossamer*	2	770	3,600	19.8	85
Rattlesnake*	1	550	2,700	17.3	63

FOR THE SECONDARY, OR ST. GEORGE'S CHANNEL, MANŒUVRES—Continued.

THE BLUE SQUADRON.

[Place of assembly: First, Falmouth; second, as ordered by Rear-Admiral Erskine.]

Ships.	Guns.	Tons.	H. P.	Speed.	Complement.	Length.
Armored cruiser:				*Knots.*		*Feet.*
Belleisle	4	4,870	3,200	12.2	282	....
Torpedo defense vessel:						
Hecla	6	6,400	2,260	11.7	273	....
Protected cruiser:						
Curlew	4	950	1,500	12	103	....
Armed tugs:						
Traveller*	2	700	1,210	12.1	53	....
Hearty	4	1,300	1,800	13	87	....
Dispatch vessel:						
Magnet*	......	430	517	12.8	....	....
Torpedo boats*:						
Nos. 45, 52, 53, 55, 57, 58, 59, 42	......	....	....	18.5	16	125
No. 60	......	....	....	20	16	125
No. 25	......	....	....	18	16	125
Nos. 65, 67	......	....	....	20	16	125
No. 73	......	....	....	22	16	125
Nos. 74, 75	......	....	....	20	16	125
No. 87 (replaced No. 85 eventually)	......	....	....	23	19	130
No. 33	......	....	....	19.8	15	130
Nos. 82, 83, 84, 85	......	....	....	22.6	19	130

The flag officers, etc., commanding fleets, divisions, and squadrons will be the following:

The Northern Fleet: Vice-Admiral Sir M. Culme Seymour, Rear-Admiral L. F. Jones.

The Western Fleet: Rear-Admiral R. O'B. Fitz Roy, C. B., Rear-Admiral N. Bowden-Smith.

The Blue Squadron: Rear-Admiral James E. Erskine.

The Red Squadron: Capt. S. Long.

The umpires will be Admiral his Royal Highness the Duke of Edinburgh, K. G., etc., Rear-Admiral R. E. Tracey.

The umpires will assemble at Devonport.

MOBILIZATION.

The Admiralty did not intend a rapid mobilization as for sudden war. On the 20th of June orders were issued that the ships about to be commissioned should be kept ready for that purpose; at the same time their commanding officers were appointed. As preparations for the manœuvres had been in progress for several months, these ships were practically ready for sea, and little remained to be done beyond receiving their crews and provisions.

The order to mobilize was telegraphed on the 8th of July. On the 9th ships were commissioned as follows at the ports mentioned:

At Portsmouth.	At Devonport.	At Chatham.	At Sheerness.
Hero.	Conqueror.	Sans Pareil.	Barracouta.
Latona.	Thames.	Narcissus.	
Iris.	Forth.	Mersey.	
Barham.	Blonde.	Medea.	
Bellona.	Spider.	Medusa.	
Barrosa.	Sharpshooter.	Salamander.	
Rattlesnake.	Spanker.	Sheldrake.	
Traveller.		Skipjack.	
Seagull.			

Torpedo boats Nos. 25, 33, 75, 42, 82, 83, 84, and 85 were put in commission at Portsmouth, and Nos. 45, 52, 53, 55, 57, 58, 59, and 60 at Devonport, on the same day. Nos. 65, 67, 73, and 74 had been commissioned at Chatham on the 30th of June.

To man the several ships and torpedo boats or to complete their crews, 6,453 men were required; this number was obtained. It was decided also to test the readiness with which the Reserves could be utilized in case of emergency.

On the 10th of July, two days after the issue of the mobilization order, 469 men, viz, 217 of the first class and 252 of the second class of the Royal Naval Reserve were reported as having joined the ships under the orders of the Admiral-Superintendent of Naval Reserves. All voluntarily offered their services, and all were embarked in addition to the complement. Further entries were then stopped, the orders to that effect being sent by telegram. Satisfactory reports on the conduct and efficiency of the men embarked were sent in at the end of the manœuvre period.

On the 13th of July, four days after the date of commissioning and five days after the order to mobilize had been received, the whole of the ships and torpedo boats had reached the places of assembly, viz, the Downs, Portland, Torbay, and Falmouth.

NORTHERN FLEET.

This fleet left the Downs on the morning of the 15th and anchored in the evening off Aldeburgh. During the next day it exercised at steam tactics, and in the evening at fog signals off Cromer. On the 17th the ships cleared for action at sea, and at night anchored at Scarborough, where they exercised with the search lights. The 18th was spent in steam tactics. During this preparatory drill period, made at 10 knots speed, the fleet acquired a precision of movement, which was lacking at first. The 19th was passed at the Tyne anchorage. The next two days were devoted to exercises under steam; on the morning of the 22nd the fleet anchored in the Firth of Forth, where, until the 25th, it was engaged in coaling.

The manœuvre cruise began on the 25th. By 4 p. m. of that day all of the vessels were underway except the *Sanspareil*, the *Aurora*, and the *Pallas*, which had difficulty in clearing their cables while unmooring. The *Pallas*, however, took her station with very little delay, and the *Aurora* was underway by 5 o'clock, but it was after seven before the *Sanspareil* started ahead at full speed, and after 10 p. m. when she rejoined the fleet. The *Ruby* was left at the anchorage to bring the mails a day or two later. A northeast course was steered to avoid the course of traffic and the fishing grounds of the North Sea. Immediately after leaving the anchorage the battle ships were formed in two divisions, the remainder of the vessels being ordered to act as scouts and connecting ships; for this purpose these vessels were extended in a T-shaped formation ahead of the flagship. While maintaining a lookout as far as possible from the fleet, they kept within touch of it, and had special orders to close in should the weather become thick. The *Sheldrake*, *Salamander*, and *Speedwell* took up their usual station abeam of the flagship.

On the 26th the position of the scouts was changed, two being ahead, two astern, and two on either beam of the divisions. As it was Sunday, no unnecessary evolutions were performed. During the afternoon the flagship communicated with the distant cruisers by means of a large red flag hoisted at the masthead and dipped to indicate the long and short dashes of the Morse code of signals. The other ships used collapsable drums in making their signals.

The northeasterly course was steered until 3 p. m. of the 27th, when the fleet headed south-southeast, being then abreast of the Shetland Islands and well out of sight of land. In the forenoon the cruisers were signalled to close in. The ships then exercised at target practice by means of rifle barrels fitted into the larger guns. The ships were rolling to a moderate swell. The shots were good in direction, though generally bad in elevation. When the firing ceased the cruisers were extended again as scouts, while the main body of the fleet exercised at steam tactics.

The object of these manœuvres thus far was to ascertain—

(1) The best organization in which to engage a hostile fleet, taking into consideration the mixed nature of the attacking force.

(2) The grouping of a fleet, in order that the weak points of one ship may be counterbalanced by the disposition of others.

(3) The most advantageous position for the Admiral's ship.

(4) The position of the smaller vessels, scouts, lookout, and connecting ships with regard to the main body of the fleet.

(5) Distant signalling.

The rendezvous at noon on the 27th was latitude 60° north, longitude 2° 30′ east; that for the 28th was to be latitude 58° north, longitude 1° 30′ east. When the cruisers were extended on the former day the *Mersey* and the *Pallas* were ordered to part company with the fleet, and, considering themselves scouts of a hostile fleet, would attempt to discover the Northern Fleet, which they had reason to suppose was cruising within an area 80 miles long by 40 miles broad. The *Pallas* was directed to cross the area from north to south on a line at 10 miles distance from the western edge, while the *Mersey* was to cross it in a north and south line from its eastern edge.

The fleet steered southwest during the night of the 27th. The *Pallas* and the *Mersey* crossed the prescribed area during daylight of the 28th. From the published accounts of the operations, it is reasonable to suppose that both vessels accomplished their mission, the *Mersey* especially, which at 10:50 a. m. saw smoke as if from the funnels of seven or eight ships in company, bearing about south-southeast, and distant probably 15 to 20 miles. The fleet meanwhile exercised at steam tactics, the cruisers keeping just within signal distance on the bow, beam, and quarter. During the afternoon a northwesterly gale arose, which continued throughout the night. The course was changed more to the westward to get under the land and out of the heavy sea. Of the four ships of the Admiral class, the *Camperdown* and the *Anson* rolled less during the gale and shipped less water than the *Rodney* and the *Howe*. All four were washed continually by the waves, and it is doubtful if with such a sea their heavy guns could be used, nor could their secondary batteries be used with full effect. The *Hero* and the *Conqueror* rolled so deep that the hull below the armor belt was much exposed. The *Sanspareil* behaved better, though heavy seas swept over the forecastle, which is about 30 feet above water The behavior of the *Nile* resembled that of the *Camperdown* and the *Anson*.

On the morning of the 29th the scouts resumed their position in line, and although the sea had moderated the contrast between the great stability of the *Immortalité* and the heavy rolling of the *Hero* and *Latona* was striking. By the afternoon the weather had cleared sufficiently to allow the fleet to be divided into two squadrons, one manœuvred by the Vice-Admiral and the other by the Rear-Admiral. The first squadron consisted of the *Camperdown* (flagship), *Howe*, *Sanspareil*, *Hero*, *Immortalité*, *Mersey*, and *Medusa;* the second, of the *Anson* (flag), *Rodney*, *Nile*, *Conqueror*, *Aurora*, *Iris*, and *Medea*. The detached squadron, composed of the *Tartar*, *Salamander*, *Speedwell*, and *Sheldrake*, lay off at a suitable distance and did not take part in the action. The *Latona* and *Pallas* had been detached for special service.

In the first encounter the squadrons passed each other in column, at 1,000 yards distance, the guns being trained to fire as soon as the adversary entered the field of fire. In the second, the Vice-Admiral's squadron passed in the indented line, and the Rear-Admiral's again in column; in this engagement the fire of the former's ships was masked at times and the weaker ships were nearer to the enemy. In the third engagement the Vice-Admiral passed in column and the Rear-Admiral in a bow and quarter line; this proved a very bad formation, the fire of several ships being masked by vessels out of station, affording a fine target for the opponents when they came abeam with the weaker ships nearest the enemy. Finally, in the fourth, the Vice-Admiral formed his ships in two divisions, each on a bow and quarter line, the four battle ships forming one division and the cruisers the other, while the Rear-Admiral's squadron was in the indented line.

In order to test the value of the experience gained by the scouting exercises already carried out, orders were issued by the Admiralty on the 30th of July to the following effect:

An enemy's fleet is sighted at the entrance of the English Channel, and is known to be proceeding toward the Straits of Dover, with probably one of the following objects:

(*a*) To enter the Thames.

(*b*) To effect a junction with another hostile fleet whose operations are confined to the Baltic.

The Northern Fleet is to try to frustrate either of these objects by preventing the enemy's fleet from passing east of the Straits of Dover. The Vice-Admiral in command can not pass west of the Straits with his battle-ships, but his scouts can search the Channel as far west as the longitude of St. Catherine Point. The coast of Great Britain will be considered neutral, so that no information can be obtained from coast guard or signal-stations.

This order was delivered about noon to the Commander in Chief by the *Latona*, which had been sent to Cleethorpes, at the mouth of the Humber, for mails and telegrams from the Admiralty. Very shortly afterwards a signal was made for steam to be ready for full speed, and this was presently followed by a general semaphore message to the fleet in the following terms: "An enemy was sighted off the entrance to the channel at daylight this morning and he may try to pass the Straits of Dover. I have sent cruisers to scout." The *Aurora*, *Mersey*, *Iris*, *Latona*, *Pallas*, and *Medusa* were detached to scout between the Isle of Wight and Cape Barfleur, 7 miles apart; and the *Immortalité*, *Medea*, and *Tartar* were to form a line south of the *Royal Sovereign* lightship.

The *Ruby* was intrusted with the mails to be sent on shore, and the battle-ships, with the three torpedo vessels, *Speedwell*, *Salamander*, and *Sheldrake*, in company, prepared for a run at full speed for the Downs. It was past 6 before all the ships were ready, though they had been steaming to the southward at 7 or 8 knots ever since the signal was made. Soon after 6 speed was gradually quickened until the squadron was proceeding at 13 or 14 knots, and this speed was more or less maintained, 13 knots being about the average until nearly 7 next morning, when a signal to reduce speed was made, the squadron being then somewhat to the southward of the North Foreland. As the flagship attained her full speed, it was clear, from the speed signals displayed by the several ships, that most of them were doing their best, and that the *Hero* and the *Conqueror* had some difficulty in keeping up with their consort, the *Nile*. The *Sanspareil*, however, being the latest out of dock, went at all times well, going at least a knot less than when she steamed independently at full speed out of the Firth of Forth to rejoin the fleet on the 25th. It should, nevertheless, be stated that the fighting complement of the *Sanspareil*, including marines, was required to reënforce the fire-room, which has a normal complement of 109 firemen.

The torpedo vessels, which have on paper a speed of 21 knots, kept their station with great difficulty. This was apparent from the thick smoke and from the flames that escaped at times from the smoke-pipe.

The distance between a line drawn from Scilly to Ushant and the Straits of Dover is 300 miles. A hostile force having once entered the Channel would be nearly sure to proceed at high speed toward its object, so that it may be assumed that this new fleet would have reached the Straits of Dover perhaps by 4 a. m. on the 31st, but not sooner, as no large fleet of battle ships, whilst preserving its formation, can maintain a speed of much more than 12 knots. The distances from the Scilly-Ushant line to the St. Catherine-Barfleur and the *Royal Sovereign* lines are 180 miles and 240 miles respectively. The enemy, therefore, might have been expected to be opposite St. Catherine at about 7 p. m. on the 30th of July and opposite the *Royal Sovereign* at about midnight.

From the mouth of the Humber to the St. Catherine-Barfleur line the distance is 300 miles, and to the *Royal Sovereign* line 240. The Northern Fleet at 1:15 p. m. on the 30th of July, when the information of the hostile fleet's approach reached it, was to the northward of the Humber, and, consequently, at least as far from the lines mentioned as the above distances. At an average speed of 15 knots it would have taken the Northern cruisers sixteen hours, or until 5:15 a. m. on the 31st, to reach the line drawn south from the *Royal Sovereign*, and twenty hours, or until 9:15 a. m. on the 31st, to reach the St. Catherine-Barfleur line. Capt. Fanshawe reports that his division of scouts averaged 14.6 knots, and Sir William Wiseman reports that his squadron, apparently for a part of the time, proceeded at 15 knots, so that the assumed speed was not exceeded. As a matter of fact, the divisions of cruisers reached the *Royal Sovereign* line at 10 a. m and 10:30 a. m. on the 31st, by which time, if the enemy had maintained his rate of speed of rather more than 12 knots an hour, he must have already passed the Straits of Dover.

One of the special difficulties of scouting service will be that of testing the value of information when the evidence is scanty, and perhaps conflicting. There was a remarkable illustration of this difficulty during the present operations. The *Mersey*, at the Cape Barfleur end of the line, between 9 and 10 p. m., on the 31st of July, sighted five steamers coming down in two groups, which led to the belief that they might be a portion of the enemy's fleet. This was communicated to the *Medusa.* The latter closed, and passed on the intelligence to the senior officer in the *Aurora,* who, as soon as he could signal to her, sent the *Pallas* to communicate it to the *Immortalité,* in the second line of scouts. Later on, the *Aurora* sighted the *Iris* steaming fast to the eastward, apparently on the heels of the enemy's ships. The *Aurora* accordingly followed her, until the *Pallas,* returning from the *Immortalité,* was met with. The last mentioned ship had received information from a German steamer that five men-of-war had been seen south of Brighton. The next intelligence was a report from the *Tartar* that four of the enemy's cruisers, one judged to be the *Narcissus* of the Western fleet, had passed to the eastward. The *Medea* had informed the *Tartar* that an enemy's cruiser had challenged her, and, as she did not answer, had put out her lights and had disappeared. Then came the *Pallas,* announcing that she had been sent by the *Aurora* to report that five steamers, believed to be the enemy, had passed between the southern scout and the French coast. Three independent sets of witnesses agreed that five steamers had passed, going to the eastward. The only discrepancy was between the *Mersey's* report that they had passed near the French coast and the German's report that they had passed south of Brighton. In reality there had been no cruisers except the Northern fleet's own scouts anywhere near, and none had passed east of St. Catherine.

On the 1st of August the battle ships anchored at the west entrance of the Downs, where they were joined by the cruisers. On the 3d, the fleet engaged in target practice, and on the 4th the manœuvres ended.

Practically, the manœuvres of the Northern Fleet had consisted of four days of cruising, of target practice with great guns and small arms, of a few tactical evolutions, and of twelve hours full speed trial, which for the fleet meant the maximum speed of the slowest vessel in it.

THE WESTERN FLEET.

On Wednesday, July 22, while the larger vessels of the Western Fleet were completing with coal, many of the smaller vessels were occupied in running Whitehead torpedoes during the afternoon, the *Barrosa* losing one of hers, and failing to recover it, although her boats were sent away in search during the whole of the following night and the next forenoon. The scouts *Narcissus* and *Barham* were ordered to have steam in readiness for full speed by 9 a. m., and the other vessels by 9:30 a. m. on Thursday, the 23d, commencing to unmoor ship and shorten in cable at 5 a. m. in readiness for leaving Bantry Bay.

At 9 a. m. on Thursday, when all was nearly ready to start, a signal was made to bank fires and to keep steam ready at half an hour's notice, it being understood that the final instructions for leaving Bantry had not been sent by the Admiralty. During the forenoon the whole of the ships were exercised at general quarters and in preparing for action, and early in the afternoon, when the day's mails had been received, the two scouts, *Narcissus* and *Barham*, were dispatched at full speed to a rendezvous off Cape Ushant, where they arrived early on Friday morning. They were ordered on arrival at Ushant to scout as though for an enemy advancing from the south; and on the sixth day out were to look for and find the Western Fleet and endeavor to gain information of its strength until chased off by superior force.

Various manœuvres and exercises of a general nature were carried out until the 27th, when the *Narcissus* and *Barham*, which had been selected as being typical ships employed by the enemy on account of their speed and armament for reconnoitring duties, left Ushant at full speed for the north and westward. Early in the afternoon of Tuesday these two vessels were discovered by the *Forth*, one of the lookout vessels of the main fleet, and she speedily signaled that an enemy was in sight of the remaining vessels of the British or Western Squadron.

In a very short space of time the *Forth* bore down upon the *Narcissus* and *Barham* and hotly engaged the former. The *Forth* then turned her attention to the *Barham*, which had put on her utmost speed, and with her consort *Narcissus*, was trying to escape. Passing across the bows of the *Barham* the *Forth* altered course eight points and steamed rapidly past her, both ships delivering broadsides at one another as they swept past in opposite directions. As soon as the *Forth* had got astern of the *Barham* and *Narcissus* she turned again in pursuit, while the *Blonde* and *Superb* in turn came up and engaged the runaway scouts, the *Superb* pouring in a fire with her heavy guns which must have had a most disastrous effect had the action been real. The *Blonde* in her turn attempted chase of the scouts, and the *Bellona* was also ordered out to give chase, but as she was about 5 miles astern of her sister, the *Barham*, the utmost she could do was to fire a few rounds from her four 7-inch guns at long range and then retire. It was evident that the superior speed of the scouts would soon put them beyond the reach of their enemies, as the *Barham* was doing at least 2 knots an hour more than her fastest pursuer, *Forth*, and could have met her sister, the *Bellona*, on even terms, supposing the latter had not been sunk by the heavier guns of the *Barham's* consort, *Narcissus*.

A signal was therefore made from the *Alexandra* to cease hostilities, and for all vessels to rejoin the main fleet, whereupon the whole of the vessels took up their appointed stations, the flagships *Alexandra* and *Swiftsure* leading their respective divisions in column, while the detached cruiser and lookout ships followed behind, with the *Narcissus* and *Barham* disposed to right and left in the rear. This formation was continued throughout the night, the vessels proceeding at a speed of 5 knots. Signal was made that in the morning the various divisions of the fleet were to have steam ready for 8 knots speed, and that they were to spread about 20 miles from each other, to carry out two days' practice with heavy and light guns at targets, the first day's exercise to consist of practice with aiming tubes and firing with the light guns, and the second day at target practice with heavy guns and Whitehead practice, after which, on the third day, the vessels were all to meet at a rendezvous 15 miles southwest of Scilly. Accordingly, on the morning of Wednesday the vessels separated in obedience to the above arrangement, leaving the *Neptune* with a signal flying that she was not under control. Wednesday was spent in firing with the light guns and aiming at targets and tube cannon practice, there being at the time a heavy swell running, with a fresh breeze and choppy sea. On Wednesday one-half the quarterly allowance of ammunition was expended, and on Thursday targets were laid out for practice with the heavy guns, when four rounds per gun were fired from each ship, the vessels steaming past the targets at a speed of 8 knots.

On the 30th it was intended to have torpedo practice, but as the choppy sea of the previous day had not gone down it was decided to proceed to the rendezvous off Scilly. In the evening all of the fleet except the *Neptune* had reassembled, and slow speed eastward was maintained during the night. Early on the 31st the *Neptune* rejoined the fleet, and a signal being made to have steam ready for 8 knots by 9:30 a. m., at that time the light vessels proceeded with their torpedo practice while the battle ships exercised at steam tactics.

The light vessels fired six torpedoes each, five of the entire number failing to run and being lost. English journals state that in the exercises of the Northern Fleet five torpedoes also failed to run.

This practice was finished by the middle of the afternoon, when the entire fleet proceeded under steam for Torbay. At 10 p. m. the *Spanker*, which had been left at Falmouth disabled, rejoined the fleet, which ended its manœuvres the next afternoon on arrival at Torbay.

THE RED AND THE BLUE SQUADRONS.

Until noon of the 22d July, when the Admiralty telegraphed that war was declared, these two squadrons were exercised at drills that were chiefly of routine character.

The General Idea of the manœuvres was as follows:

A certain portion of the east coast of Ireland is assumed to be the territory of one side called the Blue, and within its limits are six torpedo-boat stations. A certain portion of the west coast of Great Britain is assumed to be the territory of the other side, called the Red. The remaining coasts of the United Kingdom are neutral. The limits of the manœuvre area are as follows:

On the north, 55° 30′ north latitude.

On the south, 51° north latitude.

On the east, the western coast of Great Britain between 51° and 55° 30′ north latitude.

On the west, from 55° 30′ north latitude, and 6° 30′ west longitude to the Irish coast, then the eastern coast of Ireland to 8° 30′ west longitude, and then to 51° north latitude.

From Blue's stations torpedo boats may issue to act against the Red ships anchored on the opposite coast or cruising in the vicinity. The Red ships will manœuvre to prevent the torpedo boats from injuring them or interfering with their operations.

These conditions would enable the two forces to ascertain:

(*a*) The tactics to be adopted by torpedo boats stationed at several points on one shore of a channel in order to destroy or harass an enemy's ships operating in the channel or lying at anchor on the opposite shore.

(*b*) The measures necessary to afford security against these torpedo-boat attacks.

Each side was informed that the latest intelligence as to the enemy's force and disposition would be communicated to it. The Red Squadron was permitted to use the anchorages at Milford Haven, Holyhead, Luce Bay, Lough Ryan, and Campbelltown; but, except for reasons of navigation, visits were not to be made to the other ports.

The larger vessels of the Blue Squadron were intended for harbor protection, and especially as depot ships of the torpedo flotilla. The Red Squadron could wage war against the Blue and attack his depot ships; if any of the latter were kept under the fire of a certain number of the Red vessels for four hours, such ships were to be declared out of action and could take no part whatever in the operations for twenty-four hours afterwards.

Any ship of the Red Squadron struck by a torpedo was to be considered out of action.

Any torpedo boat remaining under fire of the enemy's ships for two minutes and fifteen seconds before discharging its torpedo was to be considered out of action.

Hostilities began at noon on the 22d July, the Red Squadron being concentrated in Milford Haven at the time, and the Blue Squadron being disposed as follows:

Waterford: *Curlew*, torpedo boats Nos. 60, 58, 57, and 45, and collier *Avon.*

Wexford: *Magnet*, torpedo boats Nos. 33, 65, and 53, and collier *Pansy.*

Wicklow: *Traveller*, torpedo boats Nos. 59, 55, and 53, and collier *Joseph Ricketts.*

Kingstown: *Belleisle*, and torpedo boats Nos. 82, 84, and 85.

Carlingford: *Hearty*, torpedo boats Nos. 67, 73, and 74, and collier *Grimsby.*

Carrickfergus: *Hecla*, and torpedo boats Nos. 25, 83, 42, and 52.

Directly hostilities began, the harbors which were available for the ships of the Red Squadron were to be examined by the Blue torpedo boats, and were to be constantly searched during the operations. The boats of the Kingstown group being of extra speed, were to carry out general search and patrol. Each of the other five groups had a distinct sphere of action allotted to it, so that all the anchorages of the Red Squadron, from Campbelltown to the Bristol Channel and the waters in their immediate neighborhood, would be searched, and the Red ships encountered in them be harassed or attacked. The plan of the Red Squadron included both offensive and defensive action.

At noon on the 22d the several groups of Blue torpedo boats started on the search operations assigned to them.

The *Barracouta*, *Spider*, and *Rattlesnake*, comprising the Red cruiser squadron, was sent to patrol the waters outside Milford Haven.

The *Skipjack*, *Seagull*, and *Gossamer*, forming the Red detached squadron, was dispatched to reconnoitre Wexford. The *Skipjack*, meeting with an accident to her machinery, dropped astern; the *Rattlesnake* took her place till after repairing; she rejoined the detached division during the night. The *Rattlesnake* then returned to the cruiser division. Inside the Haven the Red battle ships, with nets out, shifted berth to an anchorage between Dale Point and Stack Fort. At 7:10 p. m., the *Rattlesnake* signaled three torpedo boats astern, and the Red detached division chased them till dark. Three boats, Nos. 33, 65, and 75, approached Milford Haven and sighted the cruiser division guarding the entrance. They withdrew and on the following morning fell in with the detached division, which chased Nos. 33 and 75 into Wexford, and captured No. 65, whose steering gear had broken down. On the 23d the Red armored vessels proceeded toward Holyhead. The detached division made for Wicklow, where they saw two Blue torpedo-boats and the *Traveller*. It fired on the torpedo boats and the depot ship, the fire being returned by the latter and the militia artillery. The torpedo-boats were captured. The detached division then left Wicklow to reconnoitre Kingstown, chasing en route Nos. 82, 84, and 85, for an hour and a half, driving No. 82 into Rosslare and the others into Kingstown. On arrival at the latter port, fire was exchanged with the *Belleisle* and the forts. The ships, however, kept out of range and remained off the entrance until the next morning.

At this time the *Gossamer* left the division to fill up with coal and water, and shortly afterwards the Red battle ships and cruiser division were seen making for Kingstown. The *Shannon*, *Hotspur*, and *Northampton* had weighed at 6 a. m. on the 23d from Milford Haven, had met the cruiser division at sea, and had steered first for Wexford, then for Waterford and Holyhead, and finally, on the morning of the 24th, they appeared before Kingstown. During this passage the squadron was watched at a distance by torpedo boats, but no engagement took place.

The squadron approached Kingstown in the following order:

The *Barracouta* and the three armored ships in column.

On the left the *Rattlesnake* and *Spider*.

On the right the *Skipjack* and *Seagull*.

The latter went at first in pursuit of Nos. 75 and 82, which they sighted steering northward. After capturing them they rejoined the squadron. Capt. Long left the *Barracouta* and other light vessels outside, and entering the bay with the three armored ships, engaged the *Belleisle* and the forts. After four hours of bombardment the commander of the *Shannon* signaled the capture of the station and the ships left.

No. 59 torpedo boat, together with Nos. 53 and 55, left Wicklow at 8:40 a. m. on the 24th July, to look up Holyhead and the Red Squadron then operating off Queenstown. Having detached 53 and 55 to Holyhead, 59 eventually approached the entrance of the harbor at 12:30 p. m., and found there No. 55, No. 53 having gone up the bay to reconnoitre. At 12:45 p. m. a message from South Stack Signal Station informed the *Gossamer*, which had gone into Holyhead to coal, that torpedo boats were in sight. She left the harbor and found one boat coming in. This boat turned round to join the two others. The three boats formed in column and proceeded to sea at full speed, the *Gossamer* continuing in chase. When the latter was believed to be 2,000 yards distant, the torpedo boats went about and assumed attack formation. Each side claimed the victory; and on reference to the umpires, torpedo boats 53, 55, and 59 were adjudged to have been put out of action.

The Red Squadron then steered for Belfast with the intention of destroying the depot at Carrickfergus. In the afternoon Carlingford was passed where the *Hearty* and two torpedo boats were seen, but the squadron did not stop. Two hours before sunset intelligence was received that some of the Blue torpedo boats were following the squadron, but were some distance off. Fearing an attack before night, Capt. Long sent the *Spider* to meet them and she succeeded in scattering them. Meanwhile the *Gossamer* rejoined the squadron.

On the night of the 24th the Red scouts suddenly opened fire on a flotilla of torpedo boats, which were evidently those that had been scattered by the *Spider*.

The night was dark and foggy. Under cover of the darkness and some fishing boats two torpedo boats suddenly appeared among the armored ships. One of them discharged a torpedo at the *Northampton*, the last vessel in the line, which struck her. But as it (No. 74) had been under fire for more than five minutes it was ruled out of action. The other torpedo boat was chased by the cruisers, but carrying no lights it was soon lost to sight. The Red Squadron on the contrary had its running lights out and its search lights were not in use. It seems that the squadron commander believed that the flotilla sighted the previous evening had been scattered effectively.

At 8 a. m., on the 25th, the squadron arrived off Carrickfergus, the entrance to Belfast, where it was found that the *Hecla*, depot ship, had protected herself so thoroughly by submarine mines that she could not be attacked. The Red Squadron then proceeded to Luce Bay, where the armored ships anchored and rigged out their nets. The scouts remained on watch farther out. At 11 p. m. the *Spider* had an engagement off the Mull of Galloway with five torpedo boats, which she claimed to have put out of action, but the claim was disallowed by the umpires.

It is evident that four of these torpedo boats escaped the vigilance of the cruisers by steering under cover of the land, for at 2:50 a. m. they attacked the armored vessels. They were discovered by the search lights, and were driven off by the rapid fire guns and revolving cannon, which in fact put one of them, No. 83, entirely out of action. During the engagement, however, two of the boats succeeded in discharging their torpedoes; one of the latter missed the *Hotspur*, the central ship of the line, and was stopped by the nets of the *Northampton*. The other failed to run. Later in the morning the scouts captured No. 42, which had been in the previous engagement. The 26th was passed at anchor without incident. The *Skipjack* and *Barracouta* were sent to coal.

The night of the 26th was very dark. The torpedo boats again took advantage of a favorable opportunity for attack; only one of them, No. 27, succeeded in getting between the scouts and the land. It was discovered as it passed out of the shadow of the hills. It steamed rapidly towards the stern of the *Northampton*, and discharged a torpedo which failed to run; but during this time it was so long under the fire of the ships that it was ruled out of action.

Rear Admiral Erskine having learned that the Red Squadron was in Luce Bay, ordered Nos. 33, 53, 55, 59, 75, 84, and 85 to Belfast, to which station Nos. 25, 42, 52, and 83 already belonged. This concentration may explain the frequency of the attacks made on the Red Squadron which, while at Luce Bay, was less than 40 miles from the torpedo-boat station at Belfast.

Early on the 27th the *Gossamer*, *Skipjack*, and *Seagull* left at full speed to reconnoitre Wicklow. Opposite Kingstown they sighted Nos. 60, 57, and 58 about 10 miles off and proceeding from Ardglass to Belfast. No. 60 signaled to the two others to keep the vessels in sight, but to conceal themselves while she communicated with Ardglass station. At 3 p. m. No. 60 returned and found Nos. 57 and 58 behind Lambay Island, north of Dublin, while the *Gossamer* was south of the island. The three boats tried to hem her in between themselves and the island. The *Gossamer* opened fire and soon put them out of action.

Meanwhile the *Seagull* and *Skipjack* appeared off Wicklow, and exchanged fire with the *Traveller* and the forts. The *Gossamer*, during the afternoon, had rejoined the Red Squadron at an appointed rendezvous at sea. While on their way to Wicklow during the night two torpedo boats came up astern of the *Northampton*, one of which fired a torpedo that failed to run. The other fled when fired on. An hour later, at 2:30 a. m., Nos. 57, 58, and 60 attacked the squadron, but were driven off by the scouts before they could discharge their torpedoes. They were also put out of action.

At 8 a. m., on the 28th, the Red Squadron reached Wicklow, and after a four hours' attack, captured the station. The remainder of the day was spent at sea. No scouts were sent out, as the sea was heavy enough for protection.

On the morning of the 29th, the squadron anchored at Milford Haven. The armored ships lowered their nets. The *Barracouta* and *Seagull* were anchored so as to represent search light stations on shore. About 1:45 a. m., on the 30th, No. 84 attacked the *Shannon*, and No. 45 the *Northampton*. A torpedo from No. 84 missed the *Shannon*, but a second struck her nets. But it had remained so long under fire that it was declared out of action.

No. 45 had slipped without being seen to a point some distance from the *Shannon*, and, profiting by a passing cloud, made a bold dash for that vessel. It was discovered before discharging its torpedo, which, however, struck the *Northampton's* net and glanced, running forward. The attack was well-planned, but No. 45 was put out of action.

At noon on the 30th, the manœuvres ended; after target practice and inspection the ships returned to their respective posts.

CASUALTIES.

The following accidents are reported during the manœuvres:

The *Spanker* was delayed several days from joining the squadron by the fracture of a piston ring. The crown sheets of one of her boilers showed such signs of weakness as to prevent the use of that boiler during the operations.

The *Aurora* broke down through an accident to the low-pressure piston rod of one of her starboard cylinders, after which she proceeded under her port engine.

The *Tartar* and the *Speedwell* left the Firth of Forth on the 22d of July, the former to get a new eccentric, the latter to repair her main steam pipe.

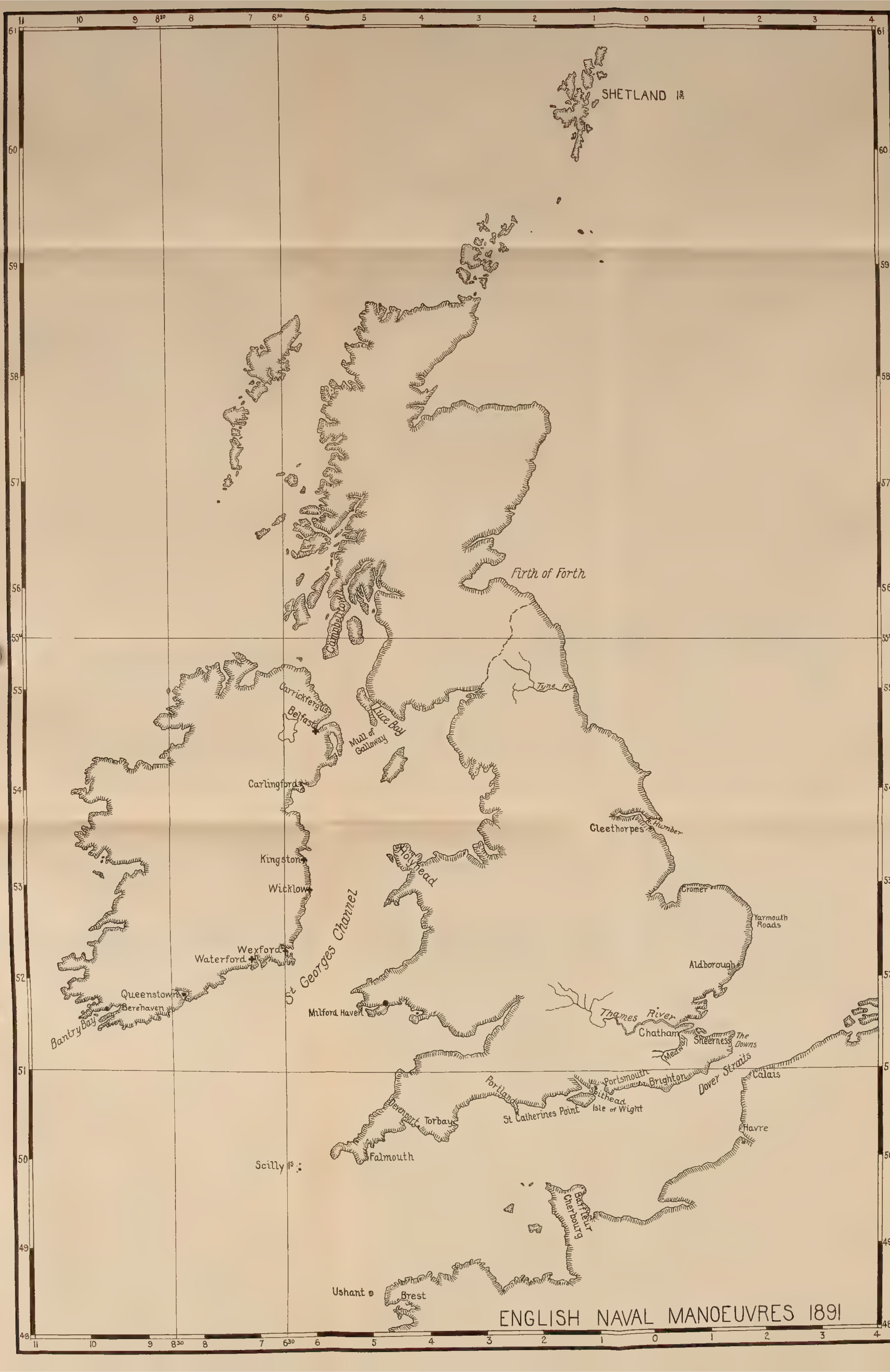
Torpedo boat No. 79 developed defects in her boilers. Only two of the torpedo boats commissioned at Portsmouth were able to leave promptly; the others were delayed by leaky boiler tubes.

On the passage to the Downs, the steam steering gear of the *Conqueror* broke down.

The *Hero*, on the 24th, lost a boat while hoisting out an anchor through the carrying away of the derrick.

On the 22d of July the *Barham* and the *Bellona* met with slight accidents to their machinery. For a similar cause on the same day, the *Skipjack* left its position in the scout division after leaving Berehaven. It did not rejoin until the next morning.

On the 27th, torpedo boat No. 85 returned to Portsmouth on account of a crack in a cylinder head, and could take no further part in the manœuvres.



ENGLISH NAVAL MANOEUVRES 1891

On the 1st of August, torpedo boat No. 82 ran aground, breaking one of her propeller blades and bending the other three, thereby reducing her speed to three knots.

COMMENTS.

The Northern Fleet was organized with care and formed a homogeneous force in which battle ships, cruisers, and torpedo vessels possessed modern features. The gale encountered by it shows the difficulty that battle ships would have in using even their secondary batteries in such weather. Several of them rolled so much as to expose the hull, thereby offering a very vulnerable target to an enemy.

The coaling operations of the Western Fleet confirmed previous experience, that coaling is far more rapid from colliers fitted with steam cranes and winches than with the resources of a port moderately equipped, as Portland, for example.

The machinery of the *Spider* class did not prove very reliable. The engines seemed too light for the work expected of them. Furnished with more powerful boilers, and possessing two knots more speed, they would be very valuable as scouts and as a protection for battle ships against torpedo boats.

The ships of the Northern Fleet, though new, were unable to maintain a greater speed than 13 or 14 knots, and the firemen had to be reënforced by men from deck. This was perhaps due to two causes. First, the ships were very unlike in size and construction, the cruisers ranging from 1,800 to 6,000 tons, while the torpedo vessels were of only 735 tons displacement. Ships so different have not the same sea qualities and can not develop the same speed under identical conditions. Second, it was impossible to relieve the firemen often enough, owing to a lack of men.

The lessons furnished by the operations of the Red and Blue Squadrons are naturally uncertain. It is impossible to make such manœuvres identical with those of war; but keeping the rules in mind it is certain that the torpedo boats failed completely. Without counting those that did not press their attacks on being discovered, sixteen torpedo boats were claimed as destroyed or captured by the Red Squadron, which also sunk two of Blue's depot ships. On the contrary, the Red Squadron lost no ships.

Eight torpedoes were discharged by torpedo boats at the enemy. Three failed to run, three missed their mark completely, one missed the vessel at which it was aimed, but struck another's net, and the eighth only was successful in hitting its target. But even in the last case the boat discharging it had been under fire for five minutes, and was therefore out of action.

With one exception the torpedo boats employed are of the most recent type. They are credited with a speed of 19 to 22.5 knots. Yet when chased by torpedo vessels or cruisers, with a speed of 17 knots, they were invariably captured. This indicates that the torpedo boats did not make more than 16 knots at sea, even when most pressed.

The failure of the torpedoes to run is due to the improper working of the water trippers. To insure action, the Admiralty has decided to fit a second water tripper.

During the eight nights of hostilities four were spent by the Red Squadron at anchor and four at sea. In the former case the armored ships had their nets lowered, and were ready to slip their cables at a moment's notice. The scouts cruised in the offing, and launches made regular rounds between the armored vessels and the scouts. In the latter case the armored ships were in column, while the light vessels acted as scouts. The torpedo boat attacks upon the squadron at anchor were the more successful. At Luce Bay the torpedo boats approached under cover of the land and attacked within good firing distance. Again, at Berehaven anchorage, when the squadron was sure that an attack would be made, a torpedo boat succeeded in firing at the *Northampton*. On the contrary, at sea only one attack had any chance of success; it happened then that the torpedo failed to run.

The fact that torpedo boats succeeded in reaching the anchorages by slipping along the coast under cover of the land suggests the need of some effective method of lighting this dangerous zone.

The manœuvres show also that torpedo boats, when left to their own resources, have great difficulty in discovering the enemy. The ships that were supposed to support them in this case were in port and were themselves an easy prey to an enemy. Of the three which were attacked, two were destroyed, and the other owed its safety only to the mines and torpedo boats by which it was surrounded. These facts suggest the conclusion that depot ships can anchor only in ports defended either by torpedoes or by batteries.

The English manœuvres for 1891 can not be said to have yielded results at all commensurate with the forces in operation. The manœuvers of former years have been mainly strategic in character. The tactical problem as to the best formation of a modern fleet for cruising and battle has not been considered seriously, it would seem.

It was shown, however, that new and complicated battle ships like the *Sanspareil* and *Nile* can be commissioned and sent to sea within a few days ready to take their station in a fleet without failure or discredit.

It may be thought that large fleets not exposed to the risk of torpedo attack are comparatively free from anxiety. Comparatively they are, but the admission only heightens the credit due to those who have sustained the burden of continuous torpedo operations without abating that due to officers who, from the time when the Northern Fleet quitted its anchorage in the Firth of Forth until it again anchored a week later in the Straits of Dover, were seldom absent from the bridge of their ships for more than two hours at a time. In that period the fleet encountered a heavy gale, steamed for more than twelve hours at full speed, and probably performed two hundred evolutions, each requiring the utmost skill and vigilance on the part of the officers responsible. All the time each ship carried on the ordinary exercises of routine and discipline. Altogether, therefore, whether the manœuvres were successful or not as the performances of powerful fleets, they were eminently successful as illustrating the skill, assiduity, and endurance of the officers and men engaged. Another incident of the manœuvres was the successful firing of the 110-ton guns of the *Sanspareil.* Whether superfluous or not, these monster guns at any rate deserve to be less suspected than heretofore. But, considering the enormous share they monopolize in the organization and structure of the ship which carries them, their excessively short life (not exceeding eighty rounds at the outside), that they are only more effective than guns of a much lighter nature and much longer life against armor which few ships carry, and no ships carry in such quantity and extent as to afford a mark certain to be hit in an engagement, their real utility and efficiency are as much open to question as ever.

There is one decided distinction between the recent torpedo boat operations and those of former years. Heretofore, the defense employed by fleets and single ships has been mainly passive in character, ships and fleets acting for the most part on the defensive. The result was that the torpedo in many cases was adjudged to have had the best of it. This year Capt. Long, himself a torpedo officer of approved skill and experience, completely turned the tables on the torpedo boats by making his defense an active one. Instead of waiting for the torpedo boats to attack him, he went to attack them. In no single instance was a torpedo boat successful in her attack on an ironclad. On the other hand, as already shown, not only were two of the protecting ships stationed at the bases of the hostile torpedo boats destroyed, but of the twenty torpedo boats engaged four were adjudged to have been captured or destroyed outright, while seventeen separate attacks made by the remainder were decided to have resulted in the attacking boat being put out of action for twenty-four hours. The superiority of active over passive defense against torpedo attack is thus abundantly demonstrated, while the numerous failures of individual torpedoes are a further illustration of the uncertain character of the weapon. On the other hand, whatever estimate may be formed of the efficiency of the torpedo as a weapon, it can not be doubted that the moral effect of its introduction as an instrument of warfare must continue to be a factor of the utmost moment. The strain imposed on the officers and crews of ships exposed to torpedo attack will be intolerable for a long period.

But Capt. Long's well-conceived and very successful strategy seems to show that a vigilant commander properly supplied with vessels adapted to the purpose will sooner or later manage to abate the strain by the total destruction of the torpedo boats which impose it. The radius of action open to a torpedo boat, though much wider than was commonly supposed before the operations of last year, is still practically insignificant as compared with the radius of action of a fleet. Inside the narrow radius fleets will not remain longer than is necessary, and while within it they must be protected in the manner which Capt. Long has shown to be not only possible but effective. Outside that radius the strain will be relaxed, though even if the manœuvres of this year have proved nothing else, they have shown that a modern fleet organized for warlike purposes can not keep the sea for long without proving to the utmost the nerve, endurance, and skill of the officers and crews engaged.

A correspondent of the Times, who evidently witnessed the manœuvres of the Red and Blue Squadrons, criticises them as follows:

> During the recent operations in the Irish Sea a moving fleet of battle ships was represented by the heavy ships of the Red Squadron—the *Shannon*, *Hotspur*, and *Northampton*. These craft are at present incapable of cruising together at a greater speed than 9 knots, and one of the forms in which the problem of fleet protection was presented to their Senior Officer, Capt. Samuel Long, was, "How shall I, when these vessels are moving toward those places where I intend to utilize them, defend them against the attacks of the twenty torpedo boats which I know to be on the watch to destroy them?" He had at his disposal for the purpose the *Barracouta*, *Seagull*, *Skipjack*, *Gossamer*, *Rattlesnake*, and *Spider*, vessels which in a seaway are probably, upon the whole, as fast as any of our torpedo boats, but which in smooth water are 2 or 3 knots slower than our best ones. He endeavored to secure his object by surrounding his line of ironclads with, as it were, a screen of light craft at a distance of about a couple of miles, and it must be admitted that he succeeded fairly well. But the problem which faced him was not quite so simple as it may at first sight appear. He had not only to dispose but also to maintain his flotilla of light craft, and, in order to maintain it, he had to have one of his small ships always away coaling, for these little vessels soon exhaust the contents of their limited bunkers. Thus, the normal number of gun vessels with the squadron was but four, and Capt. Long soon discovered, if he did not already know it, that four gun vessels and a cruiser do not constitute a force sufficient to perfectly protect three ironclads cruising at night in face of a fast and watchful foe. The ironclads always moved in single line ahead;* the *Barracouta* or a small craft generally led them, and the other craft were arranged on the flanks and to the rear of the line. While the squadron cruised in this formation several attacks were made upon it. Most of them were early detected by the outlying cruisers, whose fire drove off the torpedo boats; but five boats—one on the morning of July 25, and four on the morning of July 28—got within the screen of scouts; and two of them got near enough to the ironclads to be able to discharge their torpedoes. The first of these torpedoes, fired by No. 74, hit the *Northampton* on the port quarter, but not until the boat had been under a heavy fire for nearly five minutes. The second, although discharged at short range, failed to run. Had it run it would, I feel confident, have attained its aim and put an ironclad out of action.
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> Everyone who saw and understood Capt. Long's dispositions agrees that he did all that could be done with the force at his command; and since, in spite of this, two onslaughts, which in real warfare might easily have been fatal, were made, one is driven to the conclusion that a cruiser and five gun vessels do not constitute a sufficient force for the protection at night against torpedo boats of three ironclads cruis-

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* In column.

ing at sea. After the manuœvres the Senior Officer invited the opinions of his captains upon this interesting point, and upon the general questions that were raised by the operations. These opinions were, I believe, given confidentially, and I am not able to quote them, but I can indicate their sense. The number of small craft needed to protect ironclads at sea against torpedo attack varies inversely but irregularly with the number of ironclads to be protected. For one ironclad four or even six craft are desirable; for two, seven should suffice, one being ahead, one astern, one broad on each bow, one broad on each quarter, and one coaling; for three, nine are requisite, disposed as for two, with the addition of a craft on each beam, and for every ironclad above three two small craft should be added, so that six ironclads would want fifteen small craft, and ten ironclads would want twenty-three. These numbers, it is estimated, would allow of 20 per cent of the small craft being always absent coaling, and would at the same time give as near an approach to complete protection as could be hoped for. The formation of the ironclads in line ahead* seems to be universally recommended as the best. The scouts must be far enough off to be out of danger from the fire of the ironclads, unless the guns be considerably elevated; but they must be near enough to signal with facility, and they must on no account leave their stations to chase, unless they be specially ordered by signal to do so. For driving off their assailants they must rely upon gun and small-arm fire, assisted, but only occasionally and with careful discretion, by the electric light.

It is obviously more difficult for an enemy to deliver a general concerted attack upon a fleet under steam than upon one at anchor. The fleet at sea has to be found and reported before complete dispositions can be made for assailing it, and when those dispositions have been made, and are ripe for execution, it may have so altered its course and its formation as to have unconsciously checkmated all the enemy's plans. I think it may be regarded as certain that during the recent manœuvres Capt. Long's movements, although they were not expressly designed to have this effect, did actually thus influence the course of events. For example, after the Red Squadron had quitted Milford Haven on the second day of hostilities it learned that a division of nine torpedo boats searched in vain for it in that harbor, and there are good reasons for believing that for many hours subsequently those particular boats were unable to find out whither the squadron had gone. Indeed, it would be waste of time to prove that continual movement is in itself one of the best forms of defense against torpedo attack, for the fact is plain. But ships can not be always on the move. To coal, to repair, to fill up with stores, and to recruit their companies they must from time to time anchor, and, moreover, they must occasionally anchor in open roadsteads and in undefended ports. How, then, can ironclads at anchor in undefended ports be best protected from the assaults of torpedo boats? A few years ago the answer was, by means of nets used, of course, in combination with other precautions. I am not sure that that answer can be given to-day, for in the past few years much has happened to modify the conclusions which were somewhat hastily leaped to when nets were first introduced. We have seen only comparatively small improvements in nets; we have witnessed very striking developments in torpedoes. To-day, save, perhaps, in two or three long-commissioned and exceptionally smart ships, nets are still a form of defense that requires considerable time for effective preparation. There are afloat strange stories of how certain ships in the Mediterranean can rig out their nets in ten minutes or less; but even if those stories be all true they do not touch the point. The ships in question have been in commission for some time, and their crews have attained not only a high degree of training, but also a most intimate knowledge of the appliances at their disposal, in addition to which the nets of these ships are fitted in a special manner which could not be applied to all battle ships. One must look at service fittings and ordinary conditions. The service fittings, especially in the older ironclads, are clumsy in the extreme, and it must not be expected that in war time crews will always put to sea with a full understanding of how those clumsy fittings are to be handled.

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*In column.

The experiences of the Red squadron in this direction are, I am sure, not unusual or abnormal. Here were three ironclads, all of which had for a long period been in partial commission. Each one had on board a number of officers and men who were not strange to her, and a number of other officers and men who, though strange to her, had just come from service in other men-of-war or from the Coastguard. Not one of these ships, when first she rigged out her torpedo defenses at Milford Haven on July 22, completed the work within four hours; and not one of them, when first she took in so much of her torpedo defenses as would enable her to go to sea, completed the work within two hours. Practice caused each operation to be subsequently effected with greater rapidity, but even at the end of the manœuvres, when the nets had been up and down half a dozen times, not one of the three ships could either protect herself or get in her defenses in less than half an hour. Granting, for the sake of argument, that when they are down the nets will stop a modern torpedo running at full speed, can a net defense which takes so long to handle be a desirable adjunct to a battle-ship? It is, of course, a desirable adjunct if nothing else will serve instead of it. On the other hand, it seriously cripples the mobility of the ship that uses it. It is not safe for any ship to get under way with her nets out; and, if she chooses to take the risk, she can only move at a snail's pace. Let me imagine the case of a small ironclad squadron which, anchored in an undefended harbor, has protected itself against torpedo-boat attack by means of nets fitted as nets are fitted to the majority of battle ships. Suddenly the enemy's ironclad squadron steams in sight from seaward, with the unmistakable intention of attacking in force and at once. What is to be done? With their nets out the ships can not manœuvre. To get their nets in they require at least half an hour's grace, which the enemy will not grant them. The ships must either attempt to manœuvre, in which case they will probably foul their screws, and so come to grief in that way, or they must confine themselves to fulfilling the inglorious rôle of mere floating batteries. For, in order to get in their nets, they must send some of their men over the side, and, while these men are over the side and on the booms, they can not fire their heavy guns for fear of killing their own people. This aspect of the net problem is alone sufficient to induce me to regard nets with grave distrust. But this is not all. It is by no means certain that nets do afford protection against a really determined torpedo attack. It is believed by some that our latest torpedo has power enough to enable it in certain circumstances to pierce our existing nets; and it is claimed on behalf of Captain Wilson that, even if the torpedo by itself will not do this the Wilson shears, which may be fitted to the head of the torpedo, will do it with ease. Whether this be true or not in all cases I can not say, nor does it much matter, for all experience points to the conclusion that, after one torpedo of modern type has been discharged at and exploded in contact with a ship's nets, the whole defense in the neighborhood of the explosive will be so seriously disorganized as to readily admit any second torpedo that may seek an entrance. The destruction of net defenses wrought by such a torpedo as Mark VIII will not be merely local. The explosion will not only blow a hole in the netting, it will also smash and unship one or two booms, or perhaps even a whole broadside of them; so that unless both nets and booms can be greatly strengthened, and unless also the apparatus for rigging them out and taking them in can be very much simplified, one is inclined to recommend the total abolition of nets as part of the defenses of sea-going battle ships and of cruisers. For coast-defence ironclads they should be retained; but to battle ships and cruisers a double cellular system of construction and numerous water-tight bulkheads promise to afford a much more efficient and assuredly a much less objectionable form of protection.

Apart from such protection as may be given by the structural design of the vessel, the only really trustworthy protection for a ship at anchor, as for a ship at sea, must be derived from the sleepless vigilance of the ironclad herself and of her attendant scouts, from the judicious use of the electric search-light and of quick-firing and machine guns, and from the discipline and coolness of the defending officers and crews. A battle ship anchoring in an undefended port should, as a first precaution, send her five or six small craft well into the offing, disposing them, not in a single line across the mouth of the haven, but in two lines, one a mile or two within the other. The area inside the inner line should be further patrolled by the ship's steamboats and by her second-class torpedo boats, if she have any; and special directions should be given for the thorough guarding of all narrow channels and overshadowed tracts of water through which torpedo boats might otherwise steal unobserved in the hours of darkness. In Luce Bay, on the mornings of July 27 and 28, the Blue torpedo boats took full advantage of the shadows thrown by the coast, and, creeping stealthily in, succeeded in attacking the ironclads from the northward or land side. On those occasions the ships had none of their own boats on picket and patrol duty, and the small craft in the offing were, if judged by the standard already indicated, too few in number to afford proper protection to the squadron. Yet the scouts, even then, did excellent work, and checkmated and drove off quite as many boats as managed to pass them. Had they been more numerous, and had their efforts been seconded by the ships' boats judiciously posted under the shore, it is not unlikely that nothing would have slipped through. And what applies to the attacks in Luce Bay applies with equal force to the attacks on the morning of July 30 in Dale Roads, Milford Haven. On all these occasions the efforts of the defense were hurt rather than aided by the way in which the electric search-light was used by some of the ironclads. Many years' experience of search-lights in naval sham fights convinces me that these machines, which, in certain circumstances are invaluable, are too often so utilized as to be of far more assistance to the attack than to the defense. When an ironclad, believing that torpedo boats are near her, but seeing none of them, begins flashing her search-lights in order to discover the enemy, she greatly helps her foe, who thenceforward knows exactly where and how she lies and to what quarter her uneasy suspicions are directed.

By all means cover the mouth of your anchorage with permanent and steady beams of light, so that any craft entering must cross the beams and so reveal herself; but do not let these beams proceed from battle ships, or indeed from big ships of any sort. They should be thrown only from small craft and from boats, or, still better, from points on shore. The only time, in my humble opinion, when a threatened battle ship should use her light is when she has already clearly discovered an approaching enemy. Then let her flash it full into his eyes. It will blind and puzzle him, and, falling on his hull, guns, and paintwork, it will give her a capital target for gun fire. Splendid, when thus used, was the effect of the light upon torpedo boat No. 25 in Luce Bay on the morning of July 27. From the moment when the beam struck the boat she was as good as destroyed, for she stood out so clearly that only very bad gunners could have missed her with the 3-pounder and 6-pounder Hotchkiss guns and the Nordenfelts and Gardners. The light ought not to be worked from any point very near the guns which are to be fired. The ideal position is as far as possible below them. It is, all things considered, a mistake to mount lights on bridges and chart houses. They can not be too close to the surface of the water.

I have said that the best protection for ironclads at anchor as well as at sea is supplied by a swarm of small scouts. The torpedo gun-vessels which were used by the Red Squadron for this purpose during the recent manœuvres seem to be excellently suited for the work. With every three or four of them there should be a third-class cruiser capable of keeping up with them. First-class torpedo boats, such, for instance, as Mr. Yarrow's new 130-foot craft, would, at a pinch and in certain circumstances, do almost as well as torpedo gun-vessels; but they suffer from three or four disadvantages which, for ordinary rough sea work, render them inferior. They are not such good sea boats; they are more dependent upon parent ships for supplies of fuel, water, and provisions; they can not carry so effective an armament; and they have, owing to their relative lowness in the water, a much more restricted sphere of outlook. On the other hand, the torpedo gun-vessel is at sea available for all the purposes for which a torpedo boat can be utilized. It is true that she costs about twice as much as a first-class torpedo boat, and requires the services of four times as many officers and men; yet, looking to her improved efficiency, I would suggest that she is a craft of a type which we should be wise in greatly multiplying. But it is not at all necessary to arm all torpedo gun-vessels as our new craft of the Sharpshooter type are armed. Each of these carries two 4.7 inch quick-firing and four 3-pounder quick-firing guns. Half might bear this armament. The other half would be more efficient each mounting two 14-pounder (75^{mm}.) Hotchkiss, or guns of similar calibre of the new and ingenious Maxim semiautomatic type, six 3-pounder quick-firing, and a couple of machine guns. They would then be less heavily weighted, and more fitted than they are for dealing with small cruisers, and with torpedo boats. If we possessed these vessels we should not need to build more torpedo boats in peace time; for it is well known that our shipbuilders can now turn out torpedo boats with extraordinary speed, and that, should we want a flotilla of such craft, it can always be provided in a very few weeks.

I feel that before I bring my letters on the Red and Blue manœuvres to a conclusion there are yet a couple of important points on which something ought to be said. I have noticed that in all manœuvres in which torpedo boats and torpedo gun-vessels have been engaged friends have been continually mistaken for foes, and as such have been fired at. This happened more than once this year. It is not pleasant for a scout who has done his work well at sea to be received on returning to his main force as if he were an enemy; but at present it seems impossible for him to escape occasional maltreatment in this way. Sir George Tryon, I believe, has gone so far as to lay it down as a maxim that if in war time you see a torpedo boat you should fire at it first and ask questions afterwards. I mention the point here because it is every year becoming a more serious one. There ought to be some infallible means, in peace as well as in war, of distinguishing friend from foe both by night and by day. I am not prepared to suggest a means. All I have to say is that if none be devised it will be difficult in war time to imbue with proper confidence the officers and men of our small craft. The remaining point to which I desire to call attention is the apparently haphazard and unsystematic manner in which, during the recent operations, most of the torpedo attacks were organized and carried out. There seemed to be, in the majority of instances, a conspicuous lack of coöperative and collusive effort, and the consequence was that a perfectly startling number of boats were uselessly frittered away and expended upon efforts which, had they been well concerted, might have attained tangible results with actually less loss than was suffered over the fruitless attempts which I have had to chronicle.

In considering this writer's conclusions the rules governing the manœuvres should be remembered; the most important of them are stated by an expert in the *Globe* of August 17, 1891, to be as follows:

One rule as regards a torpedo boat attacking a battle ship was that the boat, after having picked up her torpedo, even if fired successfully, was allowed only fifteen minutes to escape, and then if caught by a torpedo-catcher was adjudged to be captured and paid off. This of course operated heavily against the Blue Squadron, since the catchers were always scouting about 2 miles from the battle ships, and since the boat had to start from rest and with her bow and stern lights lit she would barely do 3 miles in the time; meanwhile the catcher would be watching her, and as soon as the fifteen minutes were up put her out of action. Looking at the practical side of the question, as to what this kind of attack teaches us for war, it must be remembered that no nation would hesitate to sacrifice one torpedo boat, or even six, to disable a battle ship. Even with nets out it is well known by experts that the ship is in a most precarious position, for the net defense suffers severely (so much so that a second torpedo fired near the same place would certainly disable the ship), and the ship is so jarred that if the torpedo were fired near the engine-room she would be unable to steam with the engines on that side, owing to broken pipes, etc. Thousands of people have seen the magnificent half model of the *Victoria* at the naval exhibition, surrounded by a net girdle to keep torpedoes off; but how many know that at least three European countries have efficient net-cutters which are fitted on to torpedoes and which, as experiments prove, cause the torpedo to go through a net as easily as a knife through butter and with as little damage to itself. These are facts; and yet by the rules a torpedo boat could be captured and paid off after a successful attack on a battle ship which would be only out of action for twenty-four hours, or, if surrounded by nets, even considered unharmed.

Again, a boat by herself, if attacking a battle ship, had only to be under fire three and a quarter minutes before firing her torpedo, and she was out of action for twenty-four hours.

The rules of the manœuvres allowed a catcher to be superior to two torpedo boats, and even to three if she could remain inside 2,000 and outside 500 yards off them for three and a quarter minutes, while if the three boats got inside 500 yards in the time the catcher was out of action for twenty-four hours. Will any one allow that a catcher is equal to even two torpedo boats approaching on the same side, but on different bearings, when it is known that they knock about as much in a sea way as a torpedo boat, that their officers and men are as soon tired out by scouting for the fleet day and night, and that they are so thin that even torpedoes with collapsible heads were not allowed to be fired at them this year for fear of knocking a hole in them—the result of last year's experience, when a severe bulge was driven in the *Grasshopper* by a torpedo fired in a glancing direction—and yet by the rules two boats, however close they might get to her unperceived, were perfectly useless against her?

FRANCE.

The mobilization for 1891 was characterized by a great display of force, more than a hundred vessels, of which forty were armored and cruising ships, being concentrated, fully equipped, in the Mediterranean and the northern ports. It proved, also, that the French authorities realize how modern rapidity of action has altered the conditions of naval war in particular; for the ships in reserve, formerly armed at leisure after the opening of hostilities, must be ready henceforth to take the sea with the least delay possible to replace or to reënforce the active fleet, which should be able to meet the enemy on the day war is declared. Several Reserve ships were therefore attached temporarily to the permanent squadrons with the view of studying war problems afloat, and it is perhaps in this that the principal interest of the manœuvres lies.

The crews of the Reserve ships were completed by two classes of the Naval Reserves, this being the first time that these men were required to serve their full period of twenty-eight days at sea. They were drawn from the Inscription Maritime, which places at the disposal of the Navy all the male coasting population from the age of 18 to 50 and which applies to nearly 118,000 men; of this number only about 50,000 are needed to man all of the fleet. The mercantile marine absorbs a large part of the remainder.

In a general levy, too, the Inscription Maritime would not furnish more than about 30,000 men as the Reserves needed to fill the vacancies in the ships. The two classes called out on the 22d of June numbered about 3,700 men. Those belonging to the maritime arrondissements of Cherbourg and Brest embarked at those ports on board ships of the Reserve specially commissioned for the occasion; those of the arrondissements of Lorient, Rochefort, and Toulon were ordered to the latter port to complete the strength of the Mediterranean Fleet and to commission the Reserve ships to be mobilized there.

The Mediterranean Fleet is composed of three divisions of three armored vessels each, with a variable number of large cruisers, torpedo vessels, and torpedo boats. For economical reasons only the first two divisions are manned fully; the third division and the larger cruisers have reduced complements. The fleet includes also a Reserve Division, consisting of three armored vessels and three cruisers, which also carry only about two-thirds of their complements. The 1,300 Reserves sent to Toulon were assigned to the ships of the Third Division and to the larger cruisers, and after that to the ships of the Reserve Division; these vessels ultimately joined the Mediterranean Fleet and took part in the great manœuvres on the coast of Provénce.

At Brest and Cherbourg the Reservists embarked on board vessels of the Reserve mobilized for the purpose, each of which proceeded to carry out the prescribed exercises on its own account.

The vessels taking part in the manœuvres were as follows:

MEDITERRANEAN FLEET.

Battle ships: *Formidable*, *Amiral Baudin*, *Dévastation*, *Courbet*, *Redoutable*, *Hoche*.

Armored cruisers: *Bayard*, *Duguesclin*, *Vauban*.

Protected cruisers: *Tage*, *Cécille*, *Lalande*, *Vautour*.

Torpedo vessels: *Dague*, *Dragonne*.

Torpedo boats, first class: *Audacieux*, *Ouragan*, *Nos. 126* and *127*.

RESERVE DIVISION.

Battle ship: *Trident*.

Coast-defense vessels: *Indomptable*, *Terrible*.

Protected cruiser: *Faucon*.

MOBILIZED FOR THE MANŒUVRES.

Battle ship: *Caïman*.

Protected cruisers: *Sfax*, *Forbin*, *Condor*.

Unprotected cruisers: *Lapérouse*, *Du Petit-Thouars*, *Desaix*.

Torpedo vessels: *Bombe*, *Couleuvrine;* and thirteen torpedo boats, which included the *Capitaine Cuny*, *Doudard de Lagrée*, *Balny*, *Challier*, *Agile*, *Capitaine Mehl*, *Déroulède*, and *No. 151*, of the first class, and *No. 68*, of the second class.

The above vessels assembled at Toulon.

MOBILIZED AT BREST.

Coast-defense vessels: *Fulminant, Tempête.*
Unprotected cruisers: *Eclaireur, Forfait, Nielly.*
Nine torpedo boats.

MOBILIZED AT CHERBOURG.

Armored cruisers: *Turenne, Vengeur.*
Coast-defense vessels: *Tonnant, Tonnerre.*
Armored gun vessels: *Cocyte.*
Protected cruisers: *Épervier.*
Unprotected cruisers: *Fabert, Duguay-Trouin.*
Fourteen torpedo boats.

By the 23d of June 1,200 of the Reserves had arrived at Brest; during the afternoon the ships received their crews and took in coal and provisions. By 3 p. m. the *Tempête* had put out into the roadstead; and for the exercises at this port and at Cherbourg it is sufficient to state, as already implied, that they were confined to the ordinary drills, each of the larger ships acting singly for the special instruction of the Reserves. The *Fulminant* started to sea on the morning of the 29th, but had to return on account of an accident to her machinery. All of the ships at these ports were exercised both at anchor and at sea. On the 27th the torpedo boats at Brest left port in a northerly direction for a week's manœuvres, but had to put back in consequence of bad weather; and on the 9th of July it was reported that this flotilla had been prevented by bad weather from doubling Cape St. Mathieu, and later, when this was at last accomplished, it had almost equal difficulty in doubling Cape Frétel. Only three of these boats, however, were of the most recent type. On the 29th twelve torpedo boats left Cherbourg for Caen, their crews composed of Reserves. During the exercises at Cherbourg an explosion occurred on board *No. 131*, by which one sailor was killed and two injured.

At Toulon the exercises were divided into equal periods of drill, cruising, and tactical manœuvres.

At 11 a. m., 23d of June, the Mediterranean Squadron had received its Reserves, and got under way in obedience to an order from Paris. It was organized as follows:

FIRST DIVISION.

Vice-Admiral Duperré, Commander in Chief. *Formidable, Courbet, Dévastation,* battle ships; *Cécille,* protected cruiser; *Desaix,* unprotected cruiser; *Dragonne,* torpedo vessel; and three torpedo boats.

SECOND DIVISION.

Rear-Admiral Dordolot des Essarts, Commanding. *Hoche, Amiral Baudin, Redoutable,* battle ships; *Tage,* protected couiser; *Dague,* torpedo vessel; and three torpedo boats.

THIRD DIVISON.

Rear-Admiral Puech, Commanding. *Vauban*, *Bayard*, and *Duguesclin*, armored cruisers; *Lalande* and *Vautour*, protected cruisers; and three torpedo boats.

The squadron shaped its course to meet a supposed enemy coming from Corsica. The *Cécille* and the torpedo boats *Challier*, *Capitaine Mehl*, *Doudard de Lagrée*, and *Nos. 68* and *151* were left to guard the coast, while the Reserve Division embarked its Reserves. The *Tage* was sent ahead to reconnoitre Ajaccio.

The Reserve Division was ready for sea on the following day, and was dispatched to cruise between Toulon and Marseilles; at the same time the vessels of the Mobile Defense proceeded to their stations along the coast.

The *Tage* arrived off Ajaccio, saw no war ships in the roadstead, retraced its course and rejoined the squadron at 2 a. m. that night. Meanwhile the squadron had been steering towards Corsica at a speed of 10 knots, and scouted only by the *Lalande*, which kept within signal distance. The torpedo vessels were between the battle ships, and, along with the torpedo boats, were not used for scouting.

When the *Tage* signaled the absence of the enemy the squadron went about and stood for Marseilles. At the same time the *Tage* was ordered to search for the *Cécille* and to direct her to rejoin the squadron with her torpedo boats. At 2 o'clock on the same night the operations of the latter force were interrupted by a collision between the torpedo boats *Capitaine Mehl* and *No. 151*. The *Mehl* started at once for Toulon.

On the 23d a long conference took place between Admiral Rieuner, Commander in Chief of the Maritime Department, and intrusted with the defense of Toulon and the adjoining coast, and the General commanding the Fifteenth Army Corps, in order to insure coöperation between the land and naval forces if necessary during the manœuvres.

On the evening of the 24th the squadron anchored at Marseilles, having detached the Third Division for observation off Cette. At 9 p. m. the squadron exercised at general quarters.

Next morning at 7 o'clock the First and the Second Divisions got under way and stood eastward. They were joined off Toulon by the Reserve Division and the *Forbin*, and later by the Third Division from Cette. Before noon the squadron anchored in the Salins d'Hyères.

The mobilized ships when ready for service proceeded also to the Hyères Islands. The *Caïman* and *Condor* arrived there on the 26th, and were followed the next day by the *Coulcuvrine*, *Du Petit-Thouars* and the *Lapérouse*. On the last date Vice-Admiral Duperré found himself commanding a fleet of more than sixty vessels, including the torpedo boats of the Mobile Defense at Toulon, which, after receiving their quota of Reserves, joined his flag. This was the most imposing concentration of naval force that has occurred in France since the Crimean war.

The junction of the four divisions concluded the first phase of the manœuvres. The exercises between the 23d and the 26th were regarded as more successful than the mobilization. The success of the latter was modified by the tardy arrival of some of the Reserves. These delays were mitigated though by the fact that the Reserves of sixty-three departments assembled at Toulon.

From the 25th of June to the 4th of July the fleet was occupied in drilling and instructing the Reserves. Constant alarms by day and night, getting under way for torpedo and target practice, scouting exercises, torpedo attacks, and, in short, the daily programme at the Salins d'Hyères included the details of every operation that can be carried on by a modern fleet at sea.

Steam tactics and evolutions by the whole fleet occupied the 27th of June. At 8 o'clock three light divisions, each composed of a cruiser and a torpedo vessel, traversed at high speed the waters in the vicinity of the islands. These vessels maintained a distance from each other of 18 kilometres, extreme signal range, and all intelligence obtained about the movements of some ships representing an enemy's fleet was signaled rapidly to the Vice-Admiral.

At 8:30 the squadron put to sea, followed at 9 o'clock by the Reserve Division, and at 9:30 by a fourth light division, which was ordered to keep up communications between the different divisions of the fleet. At the latter hour, in beautiful weather, the evolutions at high speed commenced. During the whole day the divisions were frequently required to change direction, the whole moving in the shape of a spider's web at least 100 kilometres in diameter. The Reserve Division, 3 miles in rear of that commanded by Vice-Admiral Duperré, manœuvred with perfect precision, prepared at any moment to form line and to reinforce any division that might be attacked.

On the 28th the Admirals made a rigid inspection of the ships manned by the Reserves.

On several occasions during the remainder of the period the whole fleet put to sea, the battle ships forming the main body being screened by a chain of cruisers moving in the shape of a fan, scouting far ahead and on the flanks and maintaining constant communication with the Commander-in Chief by means of signals. On the 3d of July the *Caïman* suffered an accident to her machinery, which disabled her for more than three days, and on the same day the flotilla organized for the defense of Provence, and after a night attack on the assembled fleet joined the Vice-Admiral at Salins d'Hyères. Two torpedo boats were compelled to return to Toulon to repair damages.

Meanwhile the Mobile Defense of the coast was not inactive. Among the prominent features of its exercises was a night reconnoissance near Nice by the armored gun vessel *Achéron*, during which it was attacked by 4 torpedo boats; and the organization by Vice-Admiral Rieuner of three groups of torpedo boats for the defense of Provence. The central group, operating between St. Tropez and La Ciotat, consisted of the *Mitraille*, torpedo vessel, and 10 torpedo boats; the eastern, from St. Tropez to Menton, of the *Achéron* and 4 torpedo boats; the western, from La Ciotat to Port Vendres, of the *Fusée*, torpedo vessel, and 4 torpedo boats.

At Salins d'Hyères the 4th and the 5th of July were spent in coaling and watering the ships and in resting the crews.

For this, the third and last period of the manœuvres, the fleet was divided into two squadrons.

GENERAL IDEA.

The following General Idea was adopted:

An enemy's squadron, A, coming from Gibraltar passes between the Balearic Islands and the Spanish coast; its objective is either the coast of France or of Corsica. A French squadron, B, is directed to protect the coast, and has received intelligence by semaphore that the enemy has doubled Cape Gata, on the Spanish coast, midway between Malaga and Cartagena, and is moving in a northeasterly direction. It manœuvres to block the passage between Majorca and Barcelona, distant 100 miles from each other. The enemy's squadron has twenty-four hours start.

UMPIRES.

Vice-Admiral Duperré, as Director of the Manœuvres, hoisted his flag on board the *Desaix*.

Six captains were appointed umpires, three to each squadron.

RULES.

1. Running lights will not be carried, except by order of the squadron commanders, but will be kept ready for instant exhibition. Should a collision result from a ship exhibiting her lights too late, the captain of such vessel shall be held responsible.

2. Ships may use their search lights upon the approach of a suspicious vessel; but their continuous use, after the discovery of an enemy's ships, is positively forbidden, nor shall such light be directed upon any vessel for a longer period than ten seconds. Special care must be exercised not to blind an adversary nor to hamper his movements.

3. Battle ships and cruisers are expressly forbidden to approach within 800 metres of each other, except when passing in column of vessels on opposite courses, in which case the distance between squadrons must not be less than 600 metres. Torpedo vessels and torpedo boats must not approach within 400 metres of a hostile ship.

4. When two hostile ships or squadrons shall approach to a distance of 1,200 metres of each other, an action will be supposed to begin.

Doors of water-tight bulkheads will be closed; and, at night, running and position lights will be carried by all vessels except torpedo boats.

All commanding officers will comply with the Rules of the Road for preventing collisions.

5. An action will be supposed ended—

(*a*) If the adversaries be on opposite courses, immediately after uncovering each other.

(*b*) If, on converging courses, when they shall have been within 2,000 metres range of each other for a period of 20 minutes.

6. A vessel will not be regarded as having been in action unless—

(*a*) Acting singly it has kept for a period of twenty minutes within at least 2,000 metres range of the enemy, or has passed an enemy's vessel at a distance of at least 1,000 metres.

(*b*) As a unit of a tactical group, wherein the interval or distance is less than 1,000 metres, it shall find itself under the conditions of the preceding paragraph of this section.

7. After an action, one-half of the coefficients of the military power of the ships torpedoed shall be deducted from the sum total of coefficients for all the vessels engaged. (See paragraphs 11 and 12.)

The result of an action will be decided as follows:

8. If the total coefficients on both sides be equal, the battle will be considered a draw; the two squadrons will then separate to a distance of 50 miles by day, and 30 at night, each making half of such distance on the opposite course to that which led it to meet the other, and without the use of scouts. They recover then their liberty of action.

9. If the total coefficients be unequal—

(*a*) Then, if their ratio to each other exceeds that of 3 to 2, the weaker force shall be regarded as destroyed and shall return to Hyères Islands.

(*b*) If such ratio be equal to or less than that of 3 to 2, the weaker force shall lose one of its most powerful fighting units, which shall return to Hyères Islands. The other ships shall then separate as when the total coefficients are equal.

10. In action, the use of guns and torpedoes will be simulated on board all ships. Within a range of 2,000 metres all guns of 10 or more centimetres in calibre shall be fired once with powder and three times without it, but the number of charges consumed shall not exceed two for each piece. Rapid-fire guns and revolving cannon may fire each 4 charges, under the same conditions; riflemen may fire 6 cartridges.

Account shall be kept of all shots supposed to be fired and of all torpedoes discharged. A gun shall not be regarded as fired unless the operation of loading has been simulated, during which the projectile shall be brought from the shell room.

Guns exceeding 10 centimetres calibre shall not be used against torpedo boats.

In all firings, whether of guns or of torpedoes, ships shall not exceed their battle allowance.

11. Torpedo boats shall simulate attacks, being careful, during an action between two columns of vessels, not to go farther than 200 metres from the axis of their own column.

In event of flight by either force engaged, its torpedo boats may attack the chasing vessels, but only on the starboard side; similarly the latter's torpedo boats may attack the former force, but on the port side only.

When, in regular formation, the interval between a torpedo boat and its battle ship or cruiser is 200 metres, it shall be regarded as a torpedo vessel and shall protect the parent ship against the attack of hostile torpedo boats.

Torpedo boats shall be regarded as having beam tubes.

A torpedo boat, having exhausted its supply of torpedoes, can not simulate further attacks before obtaining a new supply from the battle ships. The latter operation shall be simulated.

12. All fighting ships, except torpedo vessels, may be torpedoed by torpedo vessels and torpedo boats; but no vessel shall be regarded as torpedoed unless two of the torpedo craft shall maintain from it a distance of 500 metres for one-half hour by day and two hours by night without exposure for more than ninety seconds to its rapid-fire guns.

Should a ship be torpedoed 4 times after the opening of hostilities, it must be considered out of service.

Torpedoed ships shall return to Hyères Islands.

13. Every torpedo boat in position for discharging a torpedo shall indicate the fact—in daylight, by hoisting signal No. 1; at night, by burning a Coston preparatory signal.

14. Torpedo boats shall not be put out of action on account of their small number.

15. The usual signals for assistance shall continue in force for torpedo boats, and all vessels in sight shall proceed immediately to their assistance.

16. After an action the Commander in Chief, or in his absence the Senior Umpire present, shall signal the result.

17. Ships out of action shall carry, in daylight, a pilot flag at the mizzen, and at night their running lights, and shall exhibit the four fixed white lanterns of the flashing signals.

18. Signals shall be made without key, excepting distinguishing signals, for which the Chiefs of Squadrons shall adopt special codes.

19. In order to distinguish similar vessels of the two squadrons those of the *Forbin*, *Vautour*, and *Dragonne* types and the torpedo boats of a squadron shall fly a red pennant under the ensign.

The signals of the *Desaix*, flagship of the Commander in Chief and Senior Umpire, shall be obeyed immediately by all vessels not excused.

The *Desaix* shall carry her running lights at night as well as her position lights when it is desirable to do so.

The Commanding Officer of each vessel shall cause a special register to be kept, in which shall be noted in detail the movements and operations of his own vessel and of all ships in sight during the manœuvres. Such register shall be forwarded to the Commander in Chief during the evening of the day on which the manœuvres shall terminate, together with a chart on which shall be plotted the routes made by the ship.

A Squadron could not attack the coast until it had passed through the channel between Majorca and Spain. In other words, it could not enter the Gulf of Lyons by passing to the southward of the Balearic Group. It could enter the channel by steaming either to the westward or to the eastward of Ivica. In the latter case it had to pass between Ivica and Formentera or else between the latter and Caprera Islands not later than 2 p. m., 9th July. The channel between Minorca and Majorca was forbidden to both squadrons.

B Squadron could not cross the 2d meridian of east longitude from Paris nor go south of the 41st parallel before 11 a. m., July 8.

The two squadrons were required to leave the Hyeres Islands in time to reach the points indicated at a speed of 8 knots.

After hostilities began the battle ships were not allowed to make more than 85 per cent of their full speed with natural draft; the cruisers could make 90 per cent of their maximum rate with forced draft; while torpedo boats could develop their highest speed.

The military power of each vessel, torpedo boats excepted, was determined by a numerical coefficient.

Before a fortified place could be considered captured the attacking force was to remain before it without interruption for six hours, three of which must be in daylight, and the force must also be superior to the land and sea forces opposed to it. To arrive at this end a numerical coefficient of military power was given to the land defense of certain ports; to establish the superiority or inferiority of the defense, this coefficient was added to that of the ships taking part in the defense, and the sum was compared with the total of the coefficients of the attacking ships.

The coefficients of the fortified ports were as follows:

Toulon,	160.	Port Vendres,	40.
Marseilles,	140.	Cette,	30.
Villefranche,	80.	Antibes,	30.
Nice,	80.	Bastia,	20.
Ajaccio,	60.		

The other ports were not supposed to be defended.

The Hyeres roadstead was neutral; hostilities were to cease at midnight of the 10th July, after which all the ships were to rendezvous at the Hyères Islands.

The average speed of the attack was greater than that of the defense, but in point of numbers the latter had the advantage.

The following table shows the composition of the two squadrons, the coefficients of military power adopted, and the speed in smooth water corresponding to the number of turns which each ship was not permitted to exceed:

A SQUADRON.

Rear-Admiral DORDOLOT DES ESSARTS, Commanding.

Ships.	Coefficient of military power.	Speed allowed in smooth water.
Battle ships:		*Knots.*
Hoche (flag)	36	13.5
Dévastation	33	12
Formidable	32	12.5
Amiral Baudin	32	12
Redoutable	30	12
Protected cruisers:		
Cécille (first class)	15	18
Lalande (third class)	8	18.4
Vautour (third class)	6	15.2
Condor (third class)	6	15
Unprotected cruiser:		
Lapérouse (second class)	12	12
Torpedo vessels:		
Dragonne	4	16
Bombe	4	16
Torpedo boats:		
Audacieux		
Capitaine Cuny		
Doudard de Lagrée		
No. 126		
No. 127		

Seventeen vessels.

B SQUADRON.

Rear-Admiral PUECH, Commanding.

Ships.	Coefficient of military power.	Speed allowed in smooth water.
Battle ships:		*Knots.*
Courbet	36	13.2
Trident (flag)	30	10.5
Caïman	30	12
Coast defense vessels:		
Indomptable	30	12
Terrible	30	12
Armored cruisers:		
Vauban	28	10.8
Duguesclin	28	11.2
Bayard	28	10.65
Protected cruisers:		
Tage (first class)	15	18
Sfax (first class)	14	14
Forbin (third class)	8	18.4
Faucon (third class)	6	15.2
Unprotected cruiser:		
Du Petit-Thouars	9	13
Torpedo vessels:		
Dague	4	16
Couleuvrine	4	15.1
Torpedo boats:		
Balny		
Challier		
Agile		
Capitaine Mehl		
Déroulède		
No. 68. No. 151. } Supposed to have torpedo tubes		

Twenty-five vessels.

Three local defense vessels, *Achéron* (armored gun vessel), *Fusée*, and *Mitraille* (torpedo vessels) were added to this squadron. Their coefficients were, respectively, 12, 10, and 10.

The coefficient of the *Du Petit-Thouars* is larger than that of the *Forbin* and *Faucon* on account of her greater gun power.

At 4 p. m. of the 6th July the *Desaix* hoisted the flag of Vice-Admiral Duperré.

About 5 a. m. the next day A Squadron got under way and steered southwest for the Balearic Islands. Six vessels, representing four light divisions, were distributed as follows: First division, the *Cécille* and *Lalande;* second, the *Condor;* third, the *Lapérouse* and *Dragonne;* fourth, the *Vautour*.

At almost the same hour B Squadron weighed and stood westward to watch the line between Barcelona and Majorca.

About 6 a. m. the *Desaix* followed A Squadron, whose movements it was to observe.

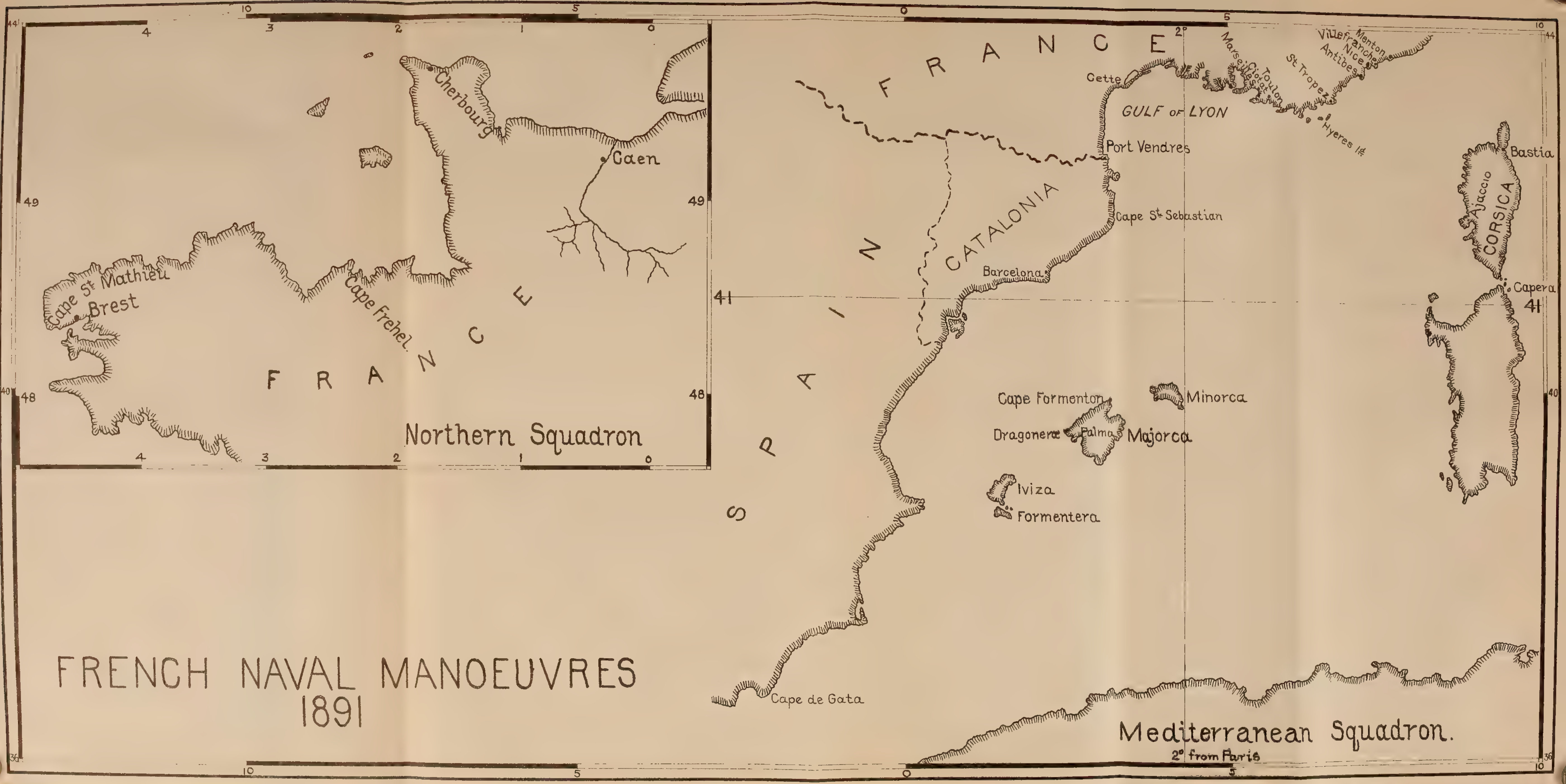
Hostilities were to begin on the 8th. A Squadron, in column of vessels, crossed the line between Formentera and Caprera islands at 3:25 p. m. that day. Its first light division (*Cécille* and *Lalande*) with the *Dragonne*, was sent ahead to reconnoitre the entrance to Balearic Channel and to make sure that no ships of B Squadron were stationed in observation; these vessels left the squadron with the understanding that it would round Dragonera Island at 9:30 that evening. The squadron did not reach Dragonera, however, till 11 p. m.

Meanwhile B Squadron was approaching its field of action. At 8 a. m. on the 8th it crossed the second degree of east longitude from Paris, and at noon was in sight of Cape St. Sebastian, on the coast of Catalonia. At 9 p. m. it arrived on the line of observation, and, reducing speed, the armored ships in column of vessels steered a course between Cape Formentor (Majorca) and Barcelona, but not approaching either coast nearer than 30 miles. The *Faucon* and *Dague*, constituting the third light division, with the *Du Petit-Thouars*, *Balny*, and *No. 151* as the fourth light division, were disposed ahead and astern of the squadron, the former toward the southeast and the latter toward the northwest. On a parallel, but 15 miles west of the squadron, the first light division, composed of the *Tage* and *Forbin*, cruised between the land and a point 25 miles off the coast of Majorca, and the second light division, *Sfax* and *Couleuvrine*, also 15 miles west of the squadron, cruised between the mainland and a point 25 miles off the Spanish coast. The ships kept their stations very well, though the night was dark and the weather stormy and squally; moreover they exhibited no lights.

As A Squadron, after passing Dragonera, kept close under the north coast of Majorca, it seems probable that it would have passed through Balearic Channel without being observed but for the fact that the sea was too rough for the torpedo boats, which about 2 a. m. on the 9th burned signals to indicate that they could no longer keep up with the large ships; this signal was observed by the *Tage* and the *Forbin.* The former leaving the latter on lookout, proceeded at once to join Admiral Puech, and at 4 a. m. signaled to him the passage of the enemy. B Squadron, at this time, was near the southeastern extremity of its cruising line, and immediately steered N. 70° E., so as to cut off a squadron making for the coast of Provence.

The wind was fresh from the northeast and the sea so rough that the torpedo boats of both squadrons rolled deeply and dropped astern. B's torpedo boats were given freedom of action under convoy of the *Du Petit-Thouars;* those of A Squadron, convoyed by the *Condor*, sought shelter in the harbor of Palma.

At 4 a. m. A Squadron passed the northeast point of Majorca and steered to clear Minorca, being joined by its first light division, which, like the others, took position on the flanks of the battle ships to lessen the chance of discovery.



FRENCH NAVAL MANOEUVRES
1891

Meanwhile, Admiral Puech had been informed by the *Forbin* that at 3:45 a. m. she had lost sight of A Squadron.

Both squadrons at this time were out of sight of each other, but were steering nearly parallel courses.

On receiving the report from the *Tage*, Admiral Puech sent the *Dague* towards Barcelona to order the second light division to rejoin the squadron and the *Tage* was again directed to secure intelligence of the enemy. After proceeding as far as 12 miles north of Minorca, the latter vessel rejoined the *Trident* at 8:15 a. m. signaling that nothing had been seen of A Squadron.

Before changing course, Admiral Puech sent the *Tage* to chase to the eastward, and at 3:50 p. m. she signaled to the *Trident* that A Squadron bore S. 50° E., distant 26 miles. During the forenoon an accident occurred to the cruiser's port propeller, which obliged her to proceed with a single screw, and hence the delay in reporting this intelligence to B.

The *Tage*, which had sighted A Squadron 16 miles off, had been observed herself at the same time. Admiral des Essarts, seeing that he had been observed since 7 p. m., decided to make for Ajaccio. He hoped that his speed would enable him to make a successful attack at this point before encountering B's ships, whose mastheads were sighted at 7 p. m. and who seemed protected in rear only, as three of his light ships were evidently away. The fact is that the *Sfax*, *Couleuvrine*, and *Dague* were left behind, and up to sunset were not in sight; and, as the *Tage's* speed was decidedly reduced and the *Forbin* and *Faucon* were having trouble with their boilers, it was impossible for B to have the scouting work efficiently performed or to attempt to surprise A's cruisers. The torpedo boats rejoined the squadron during the day, but were not in condition to make a night attack. Admiral Puech, presuming from A's course at 7 p. m. that his objective was Ajaccio, decided, under the circumstances, to continue N. 70° E. till daylight. From 3:15 a. m. on the 10th, the *Tage*, scouting ahead, observed successively the cruisers and battle ships of the enemy.

At 4:50 a. m. A Squadron opened fire on the batteries of Ajaccio, leaving the *Cécille* and *Lalande* to watch outside the bay. At 5:50 the *Cécille* signaled B's approach, and at 5:50 A Squadron was forced to proceed off to the northward, followed by B. The *Lapérouse*, steaming 10 knots, had dropped behind and was eventually hemmed in between the land and the Sanguinaires Islands by the *Indomptable*, *Trident*, and *Tage*. The latter engaged and captured her after an action of 20 minutes.

B continued in pursuit, steering towards Villefranche, but soon lost sight of A. Admiral Puech had noticed the absence of the *Condor* and torpedo boats from A's Squadron; he ordered the *Courbet* and *Forbin* to search the Corsican coast for them, and at 3 p. m., having provisioned his torpedo boats, dispatched them to make a night attack on A. But Admiral des Essarts, having now no time to operate against the coast of Provence, changed course frequently during the night to avoid B's torpedo boats.

At midnight hostilities ceased, and on the following morning the combined squadrons assembled at the Isles d'Hyères, with the exception of the *Condor* and A's torpedo boats, which had taken refuge at Palma.

On the night of the 11th the combined fleet was attacked by the torpedo-boat flotilla. On the 12th the whole force exercised at fleet evolutions. One feature was the formation of the armored ships in four divisions, the three formed by the vessels of the Mediterranean Squadron being in column of divisions and the Reserve Division two miles in rear; light cruisers were sent ahead, by twos, to reconnoitre.

On the 13th the operations terminated with an attack of the fleet upon Toulon, more than sixty vessels, including the torpedo boats, being engaged. A captive balloon, escorted by a torpedo boat, watched and reported the advance of the fleet. The defense of the roadstead was intrusted to torpedo boats, assisted by the shore batteries, which mounted one hundred and thirty-four guns. The fleet advanced in a column of thirty vessels, the *Formidable* leading, and each ship flanked by two torpedo boats. The principal point of attack was the fort of St. Mandrier, situated on the isthmus to the south of the outer roadstead, and completely commanding the approach to the harbor. After a brisk bombardment the *Formidable* succeeded in breaking through the line of defense, and the thirty ships, following each other at a distance of about four hundred yards from mainmast to mainmast, entered the harbor in spite of the smoke from the guns and took up their moorings, not ceasing their fire until the head of the line of buoys was reached.

COMMENTS.

In forty-eight hours after the decree calling out the Reserves had been issued, a fleet of twelve armored vessels in addition to the cruisers and the vessels of the Mobile Defense, were ready to meet the enemy.

The Reserves are reported to have shown great zeal and to have become quickly acquainted with the details of drill and the improvements made in the fighting mechanism of the ships. Many French papers, however, while recognizing the good will and good service of these men, do not appear satisfied with the mobilization and express doubt whether in war, when the land forces would be mobilizing also, it could be carried out without great delay and confusion. This year, though, it has the nature of experiment, and the future will show, perhaps, marked improvement.

In the first period of the manœuvres the *Tage* was sent out alone to reconnoitre Ajaccio. Though one of the fastest cruisers in the fleet, her capture at night by torpedo boats was more than a possibility, in which event there would have been no vessel to carry such intelligence to the Commander-in-Chief and to inform him of the enemy's approach.

The conditions of the defense were unfavorable, as is naturally the case where a squadron must cover a large channel and yet avoid scattering its force too far for fear of being taken at a disadvantage. Though the weather was bad and the moon obscured, yet Admiral Puech discovered the approach of his adversary by means of the *Tage* and kept touch with him as long as that cruiser was able to maintain a speed of 18 knots. This affords a striking confirmation of the importance of the rôle which cruisers will play in war.

Including the Northern division there were in commission during the manœuvres and ready for action 22 battle ships, 4 armored gun vessels, 18 cruisers, 5 torpedo vessels, and 54 torpedo boats.

Of the battle ships one was built in 1869; the others have been built during the last fifteen years. The mobilized battle ships were perhaps less prepared to work continuously without accident to their machinery. The ships commissioned from the second category of the Reserve had fire and engine room forces that had no practical experience with the machinery, however familiar with it theoretically. This is an inconvenience characteristic of Reserves.

Of the eighteen cruisers eight are wooden ships, without compartments and with a speed more than a knot less than was attained on the trial trip. They have a certain value due to armament, but can not be considered scouts for an armored squadron, for which service a speed exceeding 16 knots is necessary. Seven others had made good speed in smooth water, but their small tonnage prevented them from steaming against even a moderate gale or sea. Battle ships can not maintain a greater speed than 15 or 16 knots, and must also economize coal; an armored squadron, therefore, requires very swift, vigilant scouts to scour the sea, to discover and keep touch with the enemy, and at the same time to keep in constant communication with the Commander-in-Chief. Without very fast scouts such a squadron might encounter unawares a superior force or else allow a weaker enemy to pass at short distance under cover of night. No ship of less than 3,000 or 4,000 tons is capable of maintaining a speed of more than 16 knots, and these operations emphasize the need of very large and the swiftest possible cruisers for purposes of modern war.

The creation of a Reserve Division for the Mediterranean Squadron is due to the necessity of keeping on board these ships a sufficient personnel to handle all the machinery of whatever character; new crews can not fall into this work at once, and the need of a permanent quota perfectly familiar with the details of bulkheads, pipes, valves, etc., is evident. Under the command of a Rear-Admiral and attached to the Mediterranean Squadron, the division weighs frequently with it and takes part in the manœuvres. The vessels composing it are on the footing of the First Reserve. The results have been very satisfactory to the Ministry of Marine. By this means the best part of the battle ships will always be ready for service in forty-eight hours.

The most important lessons of the manœuvres, and one which has caused a deep impression, is the fact that the torpedo boats were unable to follow the battle ships at a speed of 12 knots even in moderate weather. Their small storage of coal and water, the excessive fatigue imposed on officers and men, where sleep and rest are out of the question, the impossibility often of cooking, make it necessary to resupply them and to change their crews every three or four days. The manœuvres have proved again that torpedo boats are not fit to be attached to a squadron on a permanent footing; if it should go to sea for more than three or four days they cease to be an additional strength, but become a worry and an impediment. On the coast they have lost none of their importance; while they remain within reach of shelter, where they can be provisioned and coaled and their crews can rest, they are of the greatest value against hostile cruisers. The manœuvres furthermore indicate that for torpedo boats, even more than for the large ships, the personnel to handle them in war should be embarked continually in time of peace for real drill, in the proportion of at least one complete crew for two boats. These facts confirm the lessons of the English manœuvres.

The cruisers *Lapérouse*, *Desaix*, and *Du Petit-Thouars*, of the Reserve, were commissioned with crews new to the machinery and were unable to maintain their estimated speed on account of the difficulty of keeping up steam. To maintain full speed it was necessary to use half the firemen instead of one-third, and even then it was necessary at times to draw on the deck force.

To summarize, the lessons derived from this year's manœuvres are the increasing importance of cruisers as scouts and the need of maintaining the number required for war; a decided condemnation of small cruisers; the limitation of torpedo boats almost exclusively to coast defense; the formation of reserve squadrons and the maintenance of reserve ships in as complete a state of equipment as possible; and the increase, if necessary, of the personnel to meet the requirements of the fire room.

GERMANY.

The German naval manœuvres were conducted with more secrecy this year than in 1890, and for this reason only they received very little comment, even in Germany. They included battle-ship tactics, torpedo-boat operations and grand manœuvres; and, during several weeks for which the operations continued, many interesting evolutions were carried out both in the North Sea and in the Baltic.

Thirty-nine vessels were brought together, forming two squadrons, as follows:

SQUADRON OF MANŒUVRES.

Battle ships: *Baden*, *Bayern*, *Oldenburg*, and *Siegfried*.

Dispatch and torpedo vessel: *Zieten;* and eight torpedo boats.

SQUADRON OF EVOLUTION.

Battle ships: *Deutschland*, *Friedrich Karl*, *Kaiser*, and *Preussen*.

Armored gun vessel: *Bremse*.

Torpedo vessel: *Jagd;* and twenty torpedo vessels and boats, including the *Pfeil* and *Blitz*, also used for dispatch service.

Vice-Admiral Deinhard was Commander in Chief.

It seems that during June eighteen of these vessels exercised in the North Sea along the west coast of Schleswig-Holstein, towards the estuaries of the Eider, the Elbe, the Weser, the Jahde, the Ems, and about Heligoland. They comprised eight armored and two dispatch vessels, two division and six torpedo boats. Towards the end of the month this squadron underwent a full-speed trial near Wilhelmshafen and Dantzig. At a later period the entire fleet was exercised in the attack and defense of the coast, in blockade work, battery firing, etc. But no operation attracted more notice than the attack made at the beginning of September upon the harbor defenses of Kiel, and especially that of the torpedo boats upon the warships in the port.

Kiel lies at the head of a deep and narrow fiord, which extends in a south-southwesterly direction about 10 miles into Schleswig-Holstein. Below Kiel, on the westward bank, rise in succession the modern and heavily armed works of Friedrichsort, Falkenstein, and Priess; and, on the eastward bank, those of Moltenort, Heidberg, Korügen, Jägerberg, Stosch, and Röpsdorf.

The defense was assisted by the Squadron of Manœuvres. The attack was intrusted to the Squadron of Evolution.

On the morning of the 3d of September, when hostilities were declared, the attacking force was at sea. The port was closed at once; that is, buoys, lights, and leading marks were supposed to be removed, and no vessels were permitted to enter without pilots. The forts were manned as for actual war. The small port of Laboe, west of Röpsdorf and close to the mouth of the fiord, was occupied by three hundred men of the Marine Battalion. The neighboring coast was lined with troops. A mine field and other obstructions were laid out between Friedrichsort and Maltenort. A number of extra batteries was planted on both coasts, and a lookout station was established at the end of Laboe pier and connected by telegraph with all the chief points of the defense. All these preparations were made within a few hours and without the slightest confusion.

Meanwhile, at an early hour in the morning, the Squadron of Manœuvres had put to sea to gain intelligence of the enemy's movements, leaving in port only the training ships *Luise*, unprotected cruiser, and the

Nixe, ship-rigged vessel with auxiliary steam power. During the day nothing worthy of note occurred, and in the afternoon the Squadron of Manœuvres returned to its anchorage, as, a gale threatening, it could not spend the dark night off the port in the known vicinity of a strong torpedo flotilla.

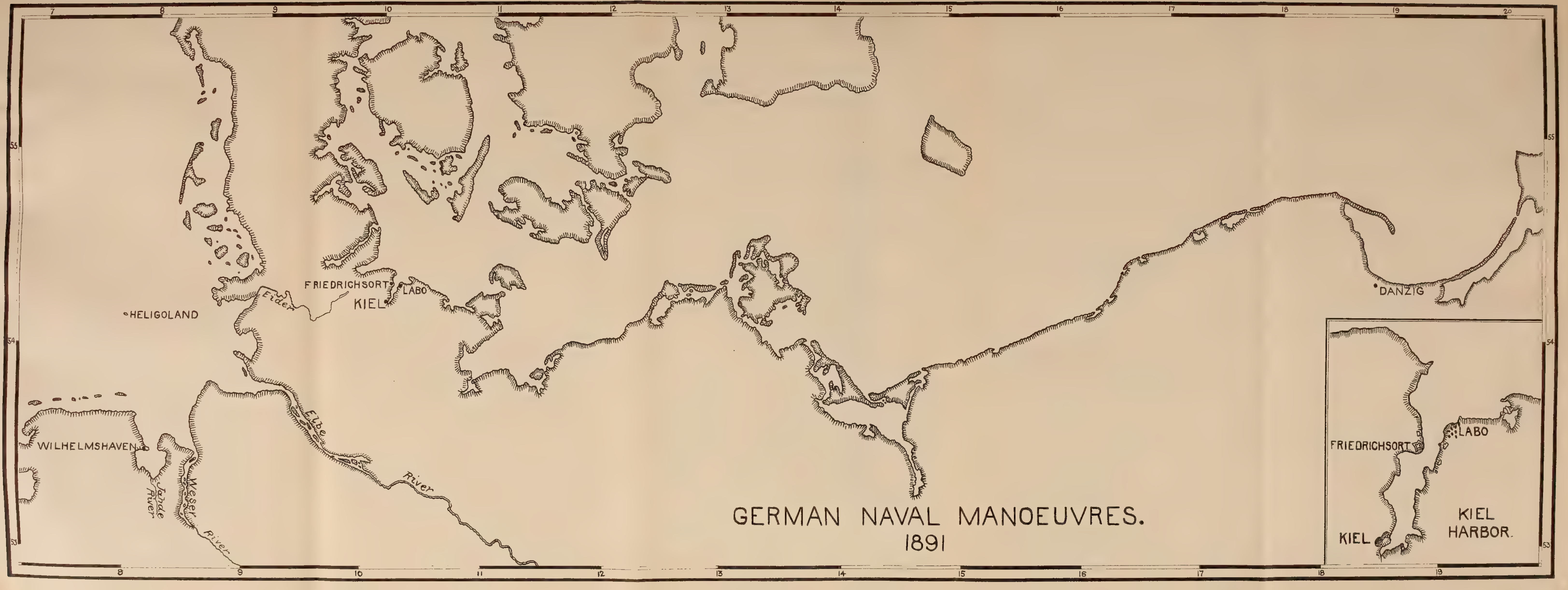
At dusk the wind was blowing half a gale, and search lights were turned upon the channel below Friedrichsort. Soon afterwards Prince Henry of Prussia made a careful inspection of all the defenses.

It was nearly midnight when the enemy's approach was signaled by rockets from the direction of Labœ. The Squadron of Evolution came within distance of the lower forts and engaged them furiously for a short time, disappearing finally to the northwest. Surprise was expressed that no torpedo-boat attack was made while the ships were occupying the general attention, and an impression prevailed that the weather was too bad for such small craft and that they had sought shelter. Just before 2 o'clock the Squadron of Evolution attacked again, more furiously even than before, and engaged not only Friedrichsort and the other forts in the narrows, but also the ships at anchor. Then through the smoke came the real attack by the torpedo fleet, which, steaming at a speed of 20 knots, got within 1,200 yards before it was discovered. A terrific fire was promptly opened upon it from everything that would bear, and it was forced to go about and make the best of its way to sea. But it tried the experiment twice again before finally relinquishing the contest.

COMMENTS.

Such an attack would scarcely be made by torpedo boats under corresponding conditions in real war. An admiral might try with his torpedo flotilla to surprise his enemy, but it is not probable that he would first rouse the defense by means of his battle ships. Nor would he be justified in sending his torpedo boats up such a long, narrow, and powerfully defended *cul-de-sac* as Kiel Fiord, unless he were pressed for time and deemed it of absolute importance to make an immediate and desperate effort. But if, in such adverse circumstances, any good could be effected by torpedo boats, it would be done by the German boats, which on this occasion were handled, as usual, to perfection.

The attack is held to demonstrate the impregnability of the port of Kiel, when properly occupied; it can not be claimed that a peace manœuvre will establish this beyond question, but it seems probable that these manœuvres went far towards proving that Kiel is safe from a sudden attack by sea, and, moreover, that war ships in its harbor can be protected completely from night raids and attacks by hostile torpedo boats.



GERMAN NAVAL MANOEUVRES.
1891

AUSTRIA.

About the first of June Admiral Sterneck, Chief of the Marine Section at Vienna, assumed command of the fleet mobilized at Pola for the manœuvres.

The fleet consisted of the following vessels:

Battle ships: *Prinz Eugen* (flag), *Rudolf*, and *Stefanie*.

Protected cruisers: *Franz Josef I* and *Lussin*.

Partially protected cruisers: *Leopard* and *Tiger*.

Torpedo vessels: *Blitz*, *Comet*, and *Traband*; eight to twenty torpedo boats.

The number of torpedo boats varied; during the tactical drills only eight were employed as a squadron, but in the battle operations the number was increased.

The manœuvres began with tactical exercises in the Gulf of Cattaro, the fleet formation consisting of three divisions, as follows:

First Division: *Prinz Eugen*, *Rudolf*, *Leopard*, *Traband*, and two torpedo boats.

Second Division: *Stefanie*, *Lussin*, *Comet*, and three torpedo boats.

Third Division: *Franz Josef I*, *Tiger*, *Blitz*, and three torpedo boats.

The *Blitz* and the *Leopard* were used occasionally as scouts.

Later, these divisions were formed into two hostile squadrons, which in the open sea executed the operations of discovery, range finding, manœuvring for position, and finally of attack at close quarters, with a dash for ramming.

On another day two squadrons were formed, as follows:

A Squadron: *Prinz Eugen*, *Rudolf*, and *Franz Josef I*.

B Squadron: *Stefanie*, *Leopard*, *Comet*, and five torpedo boats.

The former represented a squadron of armored vessels; the latter, one of cruisers and torpedo boats. The Idea of the manœuvres was an attack upon the armored vessels by the torpedo boats, supported by the fire of the cruisers. The torpedo boats, screened by the cruisers, watched their opportunities, and at a favorable moment dashed through the line of cruisers to deliver their fire at the A Squadron. During the engagement the Commander-in-Chief shifted his flag from the *Prinz Eugen* to the *Stefanie* and then to the *Franz Josef I*, being transported with his staff in a torpedo boat and from his new flagship issuing orders by signal to his squadron.

These and similar exercises covered several days. The fleet was finally divided anew into two parts, representing an attacking and a defensive squadron. The former sent out scouts to reconnoitre the coast, take soundings, discover the enemy's batteries, signal stations, etc., and to ascertain the position of the defending squadron. The latter was discovered behind a group of islands, the battle ships being cleared for action, with torpedo nets down, and all approaches well defended by temporary shore batteries armed and manned from the squadron. At night no lights were exhibited in this squadron, picket boats were posted, and a most careful lookout kept by officers and men; yet, in spite of these precautions, ten of the attacking torpedo boats approached within 200 metres of the defense vessels before discovery.

The defending squadron also cruised near Lissa, Lesina, and Curzola islands to prevent a landing by the enemy, whose operations for several days consisted of feints at landing, of evading the defending squadron, and of attempts to capture some of the coast stations. The former, however, held its own, and in the end accomplished its purpose, with the loss of one torpedo boat.

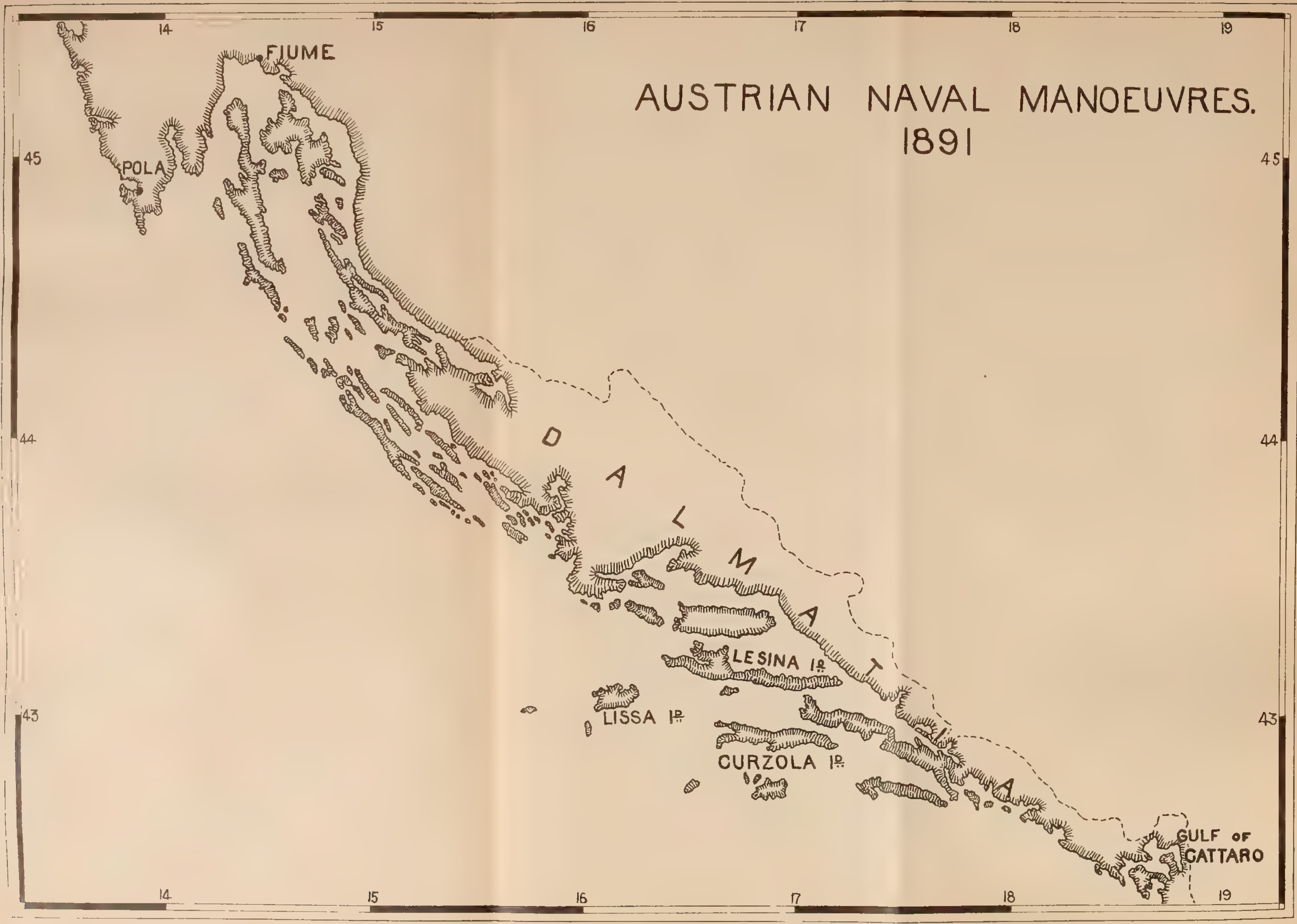
The coasts of Dalmatia and Istria are especially favorable for torpedo warfare, being fringed for about 300 miles with islands so numerous that the torpedo fleets of the world could find concealment among them. The Austrians place great confidence in the possibilities of this barrier. Several days before the end of the manœuvres the Emperor had embarked at Fiume on board the yacht *Miramar* to witness the operations of the fleet; and, in order to illustrate to His Majesty the value of these islands in such warfare, a torpedo-boat attack was arranged for the 27th of June, when the fleet was on its return to Pola.

During the afternoon of that day the *Franz Josef* and the torpedo boats were sent northward to select a position from which the attack should be made. The latter was prevented from being wholly a surprise, as it was made about 7:30 p. m., during daylight, and when the position of the torpedo flotilla might be shown by the smoke of their engines. However, the battle ships were not allowed much time for preparation, for the attacking squadron, composed of the *Franz Josef*, *Lussin*, *Leopard*, *Tiger*, *Blitz*, *Comet*, *Traband*, and twenty torpedo boats, rushed at the former under full speed and succeeded in discharging several torpedoes within the required distance of 400 metres.

COMMENTS.

The exercises seem to be very practical in character. They were executed, evidently, not for parade, but for the instruction of officers and men in manœuvring the vessels and the fleet as would be required in war. The personnel was not overworked and exhausted by needless cruising, but was kept well up to the mark in drills and manœuvres that were made thorough. From all accounts the battle operations were conducted well and the ships were handled with great nerve and skill.

The Austrian authorities are agreed that the manœuvres do not demonstrate the need of exceeding, in future constructions the size of their most recent battle ships, but that more powerful engines are necessary for them. There is also a consensus of opinion that small torpedo boats should no longer be built.



AUSTRIAN NAVAL MANOEUVRES. 1891

RUSSIA.

[Compiled chiefly from a translation made by Lieut. C. W. Jungen, U. S. Navy, from the Marine-Rundschau for January, 1892.]

For this year's manœuvres, the Baltic fleet was divided into two squadrons, as follows:

I. The Hostile Squadron.

Vice-Admiral Kasnakow, in command; Rear-Admiral Lazarew, second in command.

Ships.	Displacement.	Speed.
	Tons.	*Knots.*
Battle ships:		
Emperor Nicholas I	9,476	15
Emperor Alexander II (flag of second in command)	8,440	16
Armored cruiser:		
Herzog Edinburgski (flag)	4,602	14
Coast-defense vessel:		
Admiral Grieg	3,593	10
Partially protected cruiser:		
Rynda	2,965	15
Unprotected cruisers:		
Najesdnik	1,334	13
Wjästnik	1,334	13
Torpedo vessel:		
Lieutenant Iljin	600	18
Transports:		
Artelschik	577	....
Samoyed	771	....
Second-class torpedo boats:		
Reval	95	....
Lakta	85	....
Narwa	85	....
Ekeness	81	....

II.—THE DEFENSE SQUADRON.

Rear-Admiral Gerken in command, Rear-Admiral Walizki second in command.

Ships.	Displacement.	Speed.
Battle ship:	*Tons.*	*Knots.*
Admiral Spiridoff	3,740	10.8
Coast-defense vessels:		
Tcharodéika	2,026	8.7
Groziastchi	1,492	14.0
Unprotected cruisers:		
Skobeleff	2,400	12.0
Strelok	1,334	11.5
Plastoun	1,334	12.0
Unarmored gun vessels:		
Snjeg	402	9.0
Grosa	398	9.0
Tersch	291	9.0
Wichr	394	9.5
Burum	385	9.0
Special-service vessels:		
Slavianka	182	....
Second-class torpedo boats:		
Abo	85	....
Borgo	81	....
Kotlin	67	....
Louga	85	....
Sveaborg	95	....
8 torpedo launches	25–30	....

GENERAL IDEA.

A Hostile Squadron has obtained command of the Baltic and the Gulf of Riga and has occupied the Moon Sound, which the enemy uses as a base while blockading the Gulf of Finland and destroying the sea-borne trade, at the same time inflicting as much damage as possible on the ports from Sveaborg to Bjorkö. On learning that some of the defending ships are in Sveaborg a division of the Hostile Squadron is sent to blockade that harbor, while the remainder proceed eastward to carry out the designs against the Finnish coast. The defending squadron protects the chief trading ports from Sveaborg to Bjorkö and takes advantage of the separation of the hostile ships to attack the different divisions and single vessels. Finally, the commander of the Defense breaks out of Sveaborg and the different fiords with his squadron and proceeding to Moon Sound threatens the communications of the enemy with his base, his end and aim being to concentrate his forces by a general movement in rear of the enemy off Sveaborg.

It will be noticed that the General Idea of these manœuvres does not differ from that of 1890.

RULES.

1. On the 15th of August the entire Hostile Squadron will assemble in Moon Sound. The ships of the Defense, as detailed by the commander-in-Chief, will defend Sveaborg and the fiords to the eastward.

2. The entrances to Sveaborg and to the fortified fiords will be considered closed by submarine mines. The mine fields at Rotschensalm, in the channel leading to the Little Pellinge, and at Trangsund, are supposed to be defended by shore batteries.

3. Reval will be considered a fortified port and as defended also by mines; it will be closed to the attack. It is contemplated that part of the Hostile Squadron will take up position off Tolbuchin light-ship to blockade Kronstadt, so that the route to the fortress behind the meridian of Werkömatala is closed to the defense.

4. Porkala-Udd and Hangö-Udd are considered impregnable to attack.

5. The Hostile Squadron is forbidden the use of telegraph lines and must depend entirely upon its scouts for intelligence concerning the Defense.

6. The Defense, on the contrary, can use the telegraph lines and signal stations for transmitting intelligence.

7. The ships of the Hostile Squadron will be provisioned and coaled from Moon Sound by the transports *Artelschik* and *Samoyed.*

8. After 4 a. m., August 16, Defense vessels issuing from different fiords shall regard all merchant ships whose names they are able to ascertain and enter on the logbook as hostile transports captured while carrying stores to the enemy's squadron, provided that such Defense vessels are not destroyed or captured by the enemy, in which event the prizes, of course, are lost.

9. Hostile ships engaged in laying out mines to prevent the escape of Defense vessels must be out of range during such work and unobserved for the period actually required to perform this labor in practice; in estimating the mines laid down, no vessel can exceed the number which it is allowed to carry.

10. To prevent interference with the movements of merchant ships, the location of mines will not be indicated by buoys or other marks.

11. Twice a day the commanders of squadrons will cause to be plotted on the chart the positions of the adversary's ships according to the latest advices; vessels will be indicated by class and rate, and not by name.

12. Vice-Admiral Stezenkow will act as umpire-in-chief; Rear Admiral Makaraw and Captain Wulf as umpires. Each umpire will be assisted by two subordinate officers. Squadron commanders will communicate their plans to the umpire-in-chief.

13. Vessels will not be regarded as in action unless within 2,200 metres' range of the enemy.

14. In order that an engagement between ships may be decisive the

following conditions must be fulfilled: The engagement must last one hour and the batteries of one combatant must be twice as strong as the others in guns of like calibre. The weaker force will then withdraw from action, unless the stronger by his manœuvres has rendered capture inevitable.

15. The coefficients of guns will be as follows: 15^{cm} (6-inch) guns, 1; 20^{cm} (8-inch) and 23^{cm} (9-inch) guns, 2; 27^{cm} (11-inch) and 30^{cm} (12-inch) guns, 3; 6.3^{cm} (9 pounders) guns, ½; 47^{mm} guns, ¼.

16. The total gun coefficients of any ship represent its coefficient of military power; for example, the military coefficient of the *Emperor Nicolas I* is 26.5; *Alexander II* 26.5; *Rhynda*, 13.5; *Groziastchi*, 3.0; *Lieutenant Iljin*, 1.25; of the unprotected cruisers, 5.50; *Admiral Grieg*, 10.75; *Admiral Spïridoff*, 8.25; *Tcharodéika*, 8.

17. All ships exposed to the fire of a fort within a range of four sea miles for a period of fifteen minutes, and all torpedo boats similarly exposed within a range of one sea mile shall be considered out of action.

18. If a ship at anchor permits an enemy to approach within 550 metres with the intention of ramming, the vessel so anchored is to be considered out of action.

19. Ships declared out of action by the umpires shall withdraw and are to be considered incapable of taking further part in the manœuvres for twelve hours.

20. A battle ship shall be considered as of twice the strength of an armored cruiser and of three times that of an unarmored cruiser.

An armored cruiser shall be considered as of twice the strength of an unarmored one.

21. In action only those guns shall be fired which bear directly upon the enemy. Distances shall be determined accurately and the guns properly trained. The intervals must not be less than in rapid firing.

22. Any ship permitting a torpedo boat to approach within a range of 365 metres without firing upon it shall be considered out of action, as shall also any ship carrying torpedo nets and permitting two torpedo boats to approach within the same range.

23. A torpedo boat which, at a range of 1,280 metres or less, has been under the continuous fire of one rapid-fire gun for three minutes, or of two or three rapid-fire guns for two minutes, or of four or more rapid-fire guns for one minute, shall be considered as destroyed.

If several torpedo boats attack a ship together the conditions of the preceding paragraph will obtain for the destruction of each boat, the time being increased by one minute.

24. Torpedo boats which have discharged a torpedo must withdraw beyond range of the ship attacked before reloading. At least one-half hour must be taken for the latter operation.

25. A torpedo boat will be considered out of action:

(*a*) If attacked by two torpedo boats while under way.

(*b*) If attacked by one torpedo boat when at anchor.

26. A ship passing over an enemy's mine field without raising the mines shall be considered destroyed. If several ships in column cross a mine field without removing the mines, the leading ship shall be considered destroyed, if the channel be narrow. If the latter be broad, the leading ship and its next astern shall be considered destroyed.

27. A mine field shall be considered effective only when there are three rows of mines not more than 100 feet apart. Boats engaged in removing mines shall remain over the supposed position of each mine for a period of ten minutes before regarding the work completed. The result of such work shall be signaled by the umpire.

Besides the solution of strategic and tactical problems it was intended that the manœuvres should embrace experiments in private signals for distinguishing friend from foe, and the determination of the radius of action within which first and second-class torpedo boats can operate independently.

The manœuvres lasted from 16th to the 20th of August. The information concerning them is not complete, but a fair idea of the operations can be obtained from that at hand.

On the morning of the 16th the Hostile Squadron assembled off the western coast of Finland. The *Emperor Nicolas I* seems to have been withdrawn, as it is not mentioned in the accounts of the operations. This squadron formed three divisions, as follows:

First division: *Herzog Edinburgski*, *Rynda*, *Lakta*, and *Narwa*.
Second division: *Emperor Alexander II*, *Wjästnik*, *Reval*, and *Ekeness*.
Third division: *Admiral Grieg*, *Najesdnik*, and *Lieutenant Iljin*.

The Second Division was detailed to reconnoitre the fiords from Helsingfors to Aspö and to ascertain the strength of the enemy in that locality. Meanwhile, the First and the Third Divisions steamed eastward, but on a course more to the southward than that followed by the second. During this movement the *Lieutenant Iljin* was dispatched to reconnoitre the fiords between Aspö and Bjorkö. The squadron passed Hogland and kept to the eastward of that island during the night of the 16th, its running lights being masked. At an early hour next morning, it was joined by the *Artelschik;* this transport was utilized immediately for landing a force on the north end of Hogland and seizing the village there, an operation which met with no resistance. The Second Division then joined the rest of the squadron and reported that the fiords from Aspö to Helsingfors were unoccupied apparently, but that a large force was assembled in the latter port. Rear-Admiral Lazarew, commanding this division, was then ordered to blockade Helsingfors, and particularly to prevent the escape of any of the Defense vessels.

After the departure of the Second Division the *Lieutenant Iljin* returned and reported to the Commander-in-Chief that Bjorkö Sound and Trangsund road had been reconnoitred, that nothing had been seen of the enemy, but that it was safe to suppose a part of his squadron had assembled at Aspö. To make sure of this Vice-Admiral Kasnakow ordered the *Rynda* and the *Narwa* to reconnoitre Aspö.

Meanwhile Rear-Admiral Gerken was engaged in preparations for the defense. Several small but unequal divisions were sent to the forts near the principal towns. Helsingfors was guarded by the *Admiral Spiridoff*, *Groziastchi*, *Skobeleff*, *Grosa*, *Burum*, *Kotlin*, *Sveaborg*, and several torpedo launches. At Aspö were the *Tcharodéika*, *Strelok*, *Plastoun*, *Tersch*, *Wichr*, *Slavianka*, *Borgo*, *Louga*, and four torpedo launches. The *Snjeg* and one torpedo launch were assigned to Trangsund. When this force reached its station is unknown, but it was perhaps after the *Lieutenant Iljin* had reconnoitred this roadstead.

At 8 p. m. on the 17th the *Narwa* returned from Aspö and reported the discovery there of the *Tcharodéika*, *Strelok*, *Plastoun*, *Borgo*, and *Louga*. The two latter had surprised the *Rhynda* while reconnoitring the port, but could not discharge their torpedoes on account of a heavy sea. The *Rhynda* fulfilled the conditions of the rules in her rapid fire against them, and both torpedo boats were declared, therefore, out of action. She then steamed for Bjorkö Sound, searching for mines en route. Finding none of the enemy's vessels at the latter place, she proceeded to Trangsund and discovered there the *Snjeg* and torpedo launch, which, after a short encounter, fell easy victims to her superior strength.

While the attack was gaining these successes the Defense was not inactive. The former suffered a decided blow through the escape of the *Groziastchi* from Helsingfors. This vessel succeeded in running the blockade of the port, and, it seems, without discovery by any of the blockading ships. She then seized at sea several transports with stores for the Hostile Squadron and took them to Moon Sound, whence, after destroying all coal and ammunition found there and laying a number of mines, she returned unmolested to Helsingfors. By this operation the attacking squadron lost its base and was forced, accordingly, to establish another.

On the night of the 17th the Hostile Squadron lay at anchor off the north point of Hogland, with picket boats out, but unprepared apparently for defense against torpedoes. Upon discovering the presence of this squadron Rear-Admiral Walizki sent three torpedo boats, the *Borgo*, *Louga*, and *Kotlin*, from Aspö to attack it. They left the roads at 9 p. m.; the previously strong breeze from the southwest had moderated, but the swell was still heavy. The torpedo boats steamed against wind and sea, the *Borgo* leading. As the latter approached the north point of Hogland, she ran close under the land and, skirting the coast, sighted, at 10:50 p. m., the masts of the hostile ships. Her commander, finding that he was heading for one of the middle vessels of the squadron, changed course for a ship farther out at sea. Steaming ahead at full speed, he ran alongside of the latter, sounded several short blasts as a signal of his complete success, and then steamed back to Hogland. It was now discovered that the torpedoed ship was the *Admiral Grieg*. Her single shot at the *Borgo* was followed by the fire of the entire squadron. The *Louga* took advantage of the resulting confusion to steam through an unilluminated zone toward the stern of the *Herzog Edinburgski*, and succeeded in discharging a torpedo at close range against the latter. After this successful manœuvre the *Louga* withdrew.

The reconnoissance of Aspö led Vice-Admiral Kasnakow to suppose that the force there was weaker than his own and that he could hem it in and prevent its coöperation with the division at Helsingfors. Accordingly at daylight on the 18th the *Herzog Edinburgski* (though, according to the Rules, out of action until noon of the 18th), the *Lieutenant Iljin*, and the *Lakta* and *Narwa* proceeded to Aspö with the intention of blockading it. After raising the mines at the entrance and approaching Luppi Beacon the Vice-Admiral saw that the *Tcharodéika*, *Strelok*, and *Plastoun* were steaming at full speed for the western fiords and evidently to join the main squadron. To meet this movement the *Admiral Grieg*, *Najesdnik*, *Reval*, and *Ekeness* were signaled to join the Commander-in-Chief, who then proceeded with his force in column of vessels on a course parallel to that of the Defense ships. As the latter column was slower and weaker than that of the attacking division, Admiral Kasnakow followed it only so long as was necessary to put its ships out of action. It is not certain that he succeeded in doing this; the information concerning this operation is meagre and it is not practicable to state the actual result. During the firing the *Lieutenant Iljin* and the four torpedo boats attempted an attack upon the enemy, but in this the latter failed; the *Lieutenant Iljin* discharged two torpedoes at the *Tcharodéika*, but with what result is not known.

When the firing ceased the Hostile ships went about and stood in search of the other division of the Defense Squadron. The *Wichr* and two torpedo boats were found in a fiord, while farther away the *Slavianka* and two torpedo boats were seen coming out of Rotschensalm with the evident intention of joining Rear Admiral Walizki's division. Vice-Admiral Kasnakow ordered the *Lieutenant Iljin* to attack the *Slavianka;* the *Najesdnik*, *Lakta*, and *Narwa* were detailed to sink the *Wichr*. Neither attack was successful; the *Slavianka* escaped into the fiord, while the *Wichr* took up such an advantageous position in a narrow channel to the island of Sur-Musta that she was unapproachable. The *Lakta* and *Narwa* had followed the *Wichr* closely, but were surprised themselves by two defense torpedo boats; and being also under the rapid-fire guns of the *Wichr*, they were declared out of action. The *Lakta*, furthermore, had run aground in the narrow channel, but received no damage. The *Wichr* took advantage of the defeat of her opponents by steaming into the open sea with the two defense torpedo boats and attacking the *Najesdnik*. The latter fled or avoided action.

After these operations the Hostile division returned to the roads off Fort Slawa and anchored. The *Ekeness* and *Reval* were sent to join the blockade off Sveaborg. The night of the 18th passed without incident, and on the following morning the division got under way and anchored off the north point of Hogland Island. The *Ekeness* and *Reval* also returned to Hogland on the morning of the 19th, having been ruled out of action during an attack upon the *Admiral Spiridoff* and the *Skobeleff*. In this attack, which probably occurred off Helsingfors, these torpedo boats sunk the *Grosa*, which, supposing them to be friends, allowed them to approach within torpedo range without firing upon them.

On the 19th the Hostile Squadron remained at anchor off Hogland, coaling and provisioning from the *Samoyed* and *Artelschik*. At 6 p. m. it weighed, and stood in double column of vessels to the south of the island, and then westward. The Defense Squadron had been so weakened by the detachment of two divisions to Aspö and to Trangsund that it was not justified in threatening its enemy's rear. Nor could they be recalled in time; the only course remaining, therefore, to the Defense, was to accept battle in the Sveaborg roadstead.

At daylight on the 20th the Hostile Squadron sighted Grahara lightship, and a little later saw the Defense ships steaming out of Helsingfors towards the east. A dense fog now set in and prevented further operations during the forenoon. Meanwhile the *Emperor Alexander II.* and the *Wjastnik* rejoined the Hostile Squadron. When the fog cleared, it was evident that the Defense was ready for action. The former, in column of vessels by divisions, advanced to the attack; this formation was changed to column of vessels at a distance of 3 sea miles from the Defense ships. At 4,000 metres Vice-Admiral Kasnakow opened fire, which was returned by his opponents, also formed in column of vessels. This action occurred near Sztinas Shoal and lasted one hour. At 5 p. m. the Vice-Admiral declared the manœuvres ended.

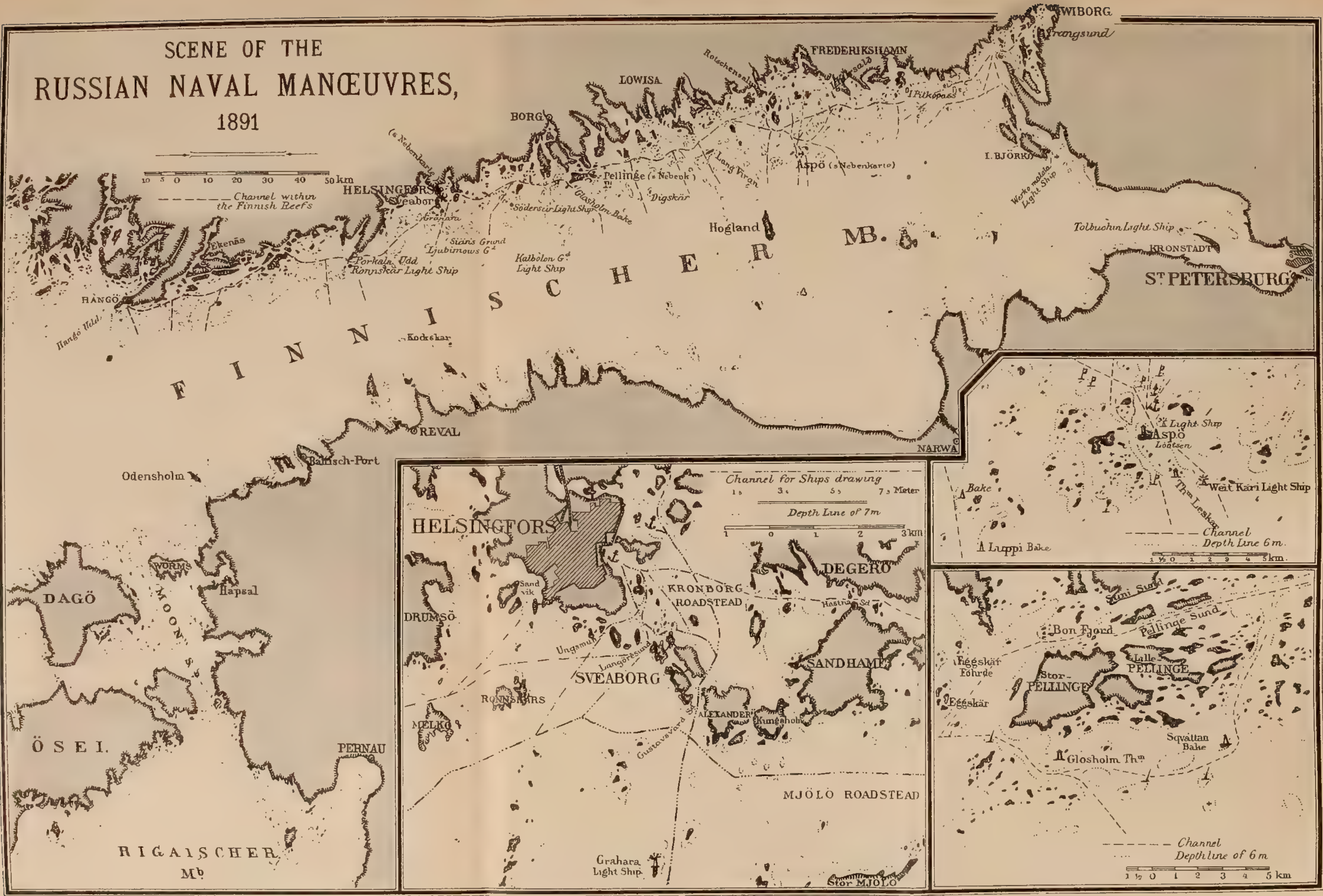
COMMENTS.

The meagre information that has reached the public concerning these manœuvres contributes very little to the solution of the strategic and tactical problems involved. The forces were inadequate and the period too short. A few features, however, deserve attention as throwing light upon the effect of local conditions outside of war principles, and hence as establishing the value of the rules and of past experience.

The General Idea represents the possible conditions which would result for Russia if attacked by an overwhelming naval force.

The limited manœuvring power of the attack, the short period, the long extent of coast, and the comparatively small forces engaged, rendered several assumptions necessary if the operations were to follow a desired line of development. The principal ports of south Finland were closed, therefore, to the Hostile Squadron, and mines and shore batteries were provided for the fiords, on which the smaller ports between Sveaborg and Bjorkö are situated. The entrances to Hangö and Porkala were considered impregnable. The other rules corresponded as nearly as practicable to the reality.

The Defense had at his disposal all the available naval resources,



SCENE OF THE RUSSIAN NAVAL MANŒUVRES, 1891

together with the land communications; the attack had to depend entirely upon his scouts. Besides, the latter could coal and provision only from the transports. The rules concerning submarine mines were exact and rigid.

The requirements concerning merchant vessels could result readily in erroneous conclusions. They were to be regarded as captured transports if the Defense vessels were able to obtain their names for entrance in the log book. More practical conclusions could be drawn had the war ships been required to maintain a position within a given distance of the merchant vessels for a stated period; and then to stop for the time that would be required to overhaul the vessel, examine her papers, and put a prize crew on board.

In action the victory was to be decided in favor of that vessel whose battery numbered twice as many guns of like calibre as that of the enemy. Each vessel's coefficient depended upon the calibres of its guns. All the ships did not carry guns of the same calibres; and yet it appears from the rules that the ship's coefficients were based in reality upon the assumption that the batteries were of like calibre guns. But, in any event, a decision based upon guns alone is rather arbitrary; in such a case armor, speed, and torpedo strength receive no weight whatever. It was a simple and easy basis of decision; one which avoided the complicated calculation that would have resulted had these several factors been introduced, and which, even if included, would not have removed necessarily all doubt as to superiority.

Large ships within 4 miles range of a fort, and torpedo boats within 1 mile range, for a period of fifteen minutes, would be exposed unquestionably to actual danger; but it is hardly in accord with actual warfare to declare a ship or torpedo boat out of action after exposure under such conditions.

It was a good rule that, in decisions, only such guns as bore on the enemy should be considered, and that the intervals between shots must be kept within the limits of rapid fire.

The rule that ships provided with torpedo nets and allowing two torpedo boats to approach within a range of 365 metres should be declared out of action seems to justify the inference that the Russians do not assign any special value to such means of defense.

The manœuvres themselves offer two incidents of special interest, the running of the blockade of Helsingfors by the *Groziastchi*, and the capture and the destruction of the Hostile Squadron's base at Moon Sound. The Hostile Commander-in-Chief left his base with all his fighting ships, and it seems that he made no preparations to defend it against attack. The failure to take such an important precaution is quite inexplicable, unless Vice-Admiral Kasnakow considered it impossible for the defense to run the blockade. By this bold act of the *Groziastchi's* commander the squadron at Hogland was not only deprived of its base, but was compelled to reëstablish it or else to withdraw from the coast until fresh supplies could be obtained. No special notice, however, was taken of this occurrence, as it would have delayed the manœuvres, which were executed apparently rather with a view to tactical instruction than to strategy.

The torpedo boat attack upon the Hostile Squadron off Hogland is another event of importance. Its success was due to the lack of proper vigilance by the latter and its failure to prepare against a surprise. A squadron anchored at a distance of 12 to 15 miles from its enemy is so liable to torpedo boat attack that the neglect of all proper precautions against it could not be justified under circumstances of actual war. Without such precautions it would be impossible to discover an attack in time to repel it. The result in this case was the loss of a coast defense vessel and an armored cruiser.

Several opportunities arose during the manœuvres to demonstrate the value of torpedo boats; their operations, though, were not always attended by definite results. They confirm the lessons, drawn from the naval manœuvres of other powers, that surprise is a necessary element of torpedo boat attack.

The action between the torpedo boats *Lakta* and *Narwa* and the unarmored gun vessel *Wichr*, off Sur-Musta, where the former were attacked and defeated so suddenly by two smaller torpedo boats is instructive. The locality here afforded a concealed position for the smaller boats and rendered it possible to surprise completely the larger ones during their attack on the *Wichr*.

VII.

ARMOR IN 1892.

By Ensign **Edward Simpson**, U. S. Navy.

During the past year the chief investigations of the development of armor for naval use have been confined to experiments in England and in the United States. Two interesting firing trials were conducted at Gâvres, last July, of Creusot nickel-steel plates, which will be discussed in this article, and competitive trials of sample plates for gun shields have also been held at Sevran-Livry. In Italy, experimental 3.94 and 5.91-inch nickel-steel plates, manufactured at the Terni Steel Works, have given such satisfactory results that nickel-steel is expected to be adopted for the new armored cruisers. Apart from these trials, the interest in the armor question at date is centered in the results obtained during the series of trials, encouraged by the British Admiralty in their search for the most efficient armor with which to protect the vessels in contemplation of building, and in those held at Indian Head, for a similar purpose, under the direction of the U. S. Navy Department.

It is the purpose of this article to review the progress made in each country during the year, from such data as is at hand, by a study of the results of the attacks on the plates and the amount of protection they would have afforded to materiel and personnel behind them. It is regretted that the composition and process of manufacture of each plate can not be given and discussed, but these are naturally trade secrets, and are held as such by the different armor makers.

The difficulties that obtain in comparing trials conducted under different conditions must not be lost sight of. Such comparisons, at best, can only be imperfect. The weight of plate, character of backing, system of bolting, striking velocity, quality, weight, and diameter of projectile, and its action on impact, etc., all tend to produce such different strains on the plate, that a competitive test, under exactly similar conditions, is the only manner in which a fair comparison of plate resistance qualities can be obtained; and even that must be dependent on the uniformity of the projectiles employed. This latter condition seems to have been met by the Holtzer a. p. projectiles; and as all *Net-*

tle 10½-inch plate trials, during the past year, have been conducted under uniform conditions, employing three of these projectiles, and they were also used at the Indian Head trials, a fairly good estimate of the relative value of the different plates is permissible.

However, as many of the trials herein discussed were conducted under different conditions, and with different types of a. p. projectiles, for the purpose of facilitating comparisons, the striking energy employed is compared, in each case, with that just necessary to perforate wrought iron of the same thickness, using, as in Chapter VI, No. X, De Marre's formula for indeformable projectiles of comparatively small calibre, with high striking velocities.

Although several of the English trials are of more recent date than those conducted at Indian Head, it is considered best, in order to avoid confusion, to discuss the subject under four heads, viz:

I. French trials at Gâvres.
II. English trials.
III. Indian Head trials.
IV. Conclusions deduced from the year's investigations.

I. FRENCH TRIALS.

On July 11th and 18th, 1891, two Creusot nickel-steel plates were tested at Gâvres by the Government Commission. These plates did not represent lots of armor for any vessel, but were merely information trials.

Test of a Creusot nickel-steel plate.

Date of trial: July 11, 1891, at Gâvres.

Details of plates: 8.26 feet by 4.99 feet by 10.43 inches attacked at the corners and centre of a square whose side was 47.2 inches. Weight of plate, 12.9 tons.

Ballistical details.

[Gun 16^{cm} (6.3-inch) B. L. R.]

Projectiles, chrome steel a. p.	pounds	99
Striking velocity	f. s.	2,158
Striking energy	f. t.	3,196
Striking energy as compared with that just necessary to perforate a wrought-iron plate of same thickness		1.50

Firing details.

First shot (right lower corner).—Projectile penetrated 12.2 inches and broke up, head remaining in plate, and base rebounding 16.4 feet. Fringe 1.4 inches high. Several fine radiating cracks from 2¼ to 2¾ inches long about shot hole.

Second shot (left upper corner).—Projectile penetrated until its base was flush with the front face of the plate. Fringe 3 inches high. Several small cracks 1½ to 2 inches long about the hole.

Third shot (right upper corner).—Projectile penetrated 11.1 inches and rebounded broken. Fringe 1.2 inches high. Four fine radiating cracks, the longest being .35 inches.

Fourth shot (left lower corner).—Projectile penetrated 16.85 inches and remained in the plate intact. Fringe 1.6 inches high. One through crack to left edge of plate, and eight small radiating cracks. A fragment of plate loosened on lower edge of shot hole No. 1.

Fifth shot (centre of plate).—Projectile penetrated 13.5 inches and remained in the plate, its base projecting 1.9 inches from the face of the plate. Fringe 0.8 inch high. Six small unimportant radiating cracks. A small piece of plate, 1.4 inches deep, broke off on right side.

With the exception of the through crack, after the fourth shot, this plate showed very similar qualities to those of the Creusot nickel-steel plate tested at Annapolis, September 18, 1890. The penetrations of the first four shots average one-fourth of an inch more, and the effects on the projectiles, none of which perforated, were about the same. Although a higher striking velocity was employed, the slightly decreased weight and increased calibre of the projectiles made the severity of the two tests for penetration about equal. The heights of the back bulges are not known, but the penetrations would seem to indicate either that the left side of the plate was the softer, or that there was an unequal distribution of nickel, as evidenced by the through crack. The plate seemed up to the standard attained by Le Creusot, and was admitted to reception by the Commission.

The second Creusot nickel-steel plate was tested for resistance to fracture from chilled cast-iron projectiles of large calibre, fired with low striking velocities.

Test of a Creusot nickel-steel plate.

Date of trial: July 18, 1891, at Gâvres.

Details of plate: 8.25 feet by 8.27 feet by 9.84 inches. attacked at corners of an equilateral triangle, sides 2½ calibres long. Weight of plate, 12.2 tons

Ballistical details.

[Gun, 24^{cm} (9.45-inch) M./70.]

Projectiles, Chatillon & Commentry chilled cast-iron	pounds	316.8
Striking velocity	f.s.	1,343
Striking energy	f.t.	3,961
Striking energy as compared with that just necessary to perforate a wrought-iron plate of same thickness:		
De Marre		1.10
Gâvres		1.09

Firing details.

First shot (right corner).—Projectile penetrated 6.14 inches and rebounded broken, the point coming 17 feet to the rear, and fragments flying 95 feet to the right. Two cracks developed, extending at right angles, one to the right and the other to the lower edge of plate.

Second shot (left corner).—Projectile broke in two pieces, the head falling 8 inches from target. A crack 0.16 inch wide extended to left side of plate. Another crack joined the two shot holes.

Third shot (upper corner).—Projectile broke into six pieces, the head falling 1 foot from target. One through crack to the top of plate, and another joining shot No. 1.

This plate illustrates the racking effect of large chilled-iron projectiles with low striking velocities. The attack for penetration was in favor of the plate, and perforation was not anticipated. Had the plate been face-hardened, much of the energy would probably have been expended in breaking up the projectile before sufficient penetration had been accomplished to allow the upsetting projectile to exercise its wedge action, resulting in through cracks. The plate, however, showed its ability to afford good protection under such attack, the penetrations were not great, no scaling or bad chipping is recorded, and although broken into four parts, the system of bolting employed held them in place so well that they were still effective against further attack. This was shown by the failure of two 24^{cm} and one 16^{cm} steel projectiles to perforate when fired at the good portions of the plate.

As a protection against projectiles, through-cracking is preferable to perforation; and, as in this case, a slightly increased striking velocity would have carried an a. p. projectile completely through, while it would not have materially increased the damage inflicted by a chilled-iron projectile, we do not believe that in future actions chilled-iron projectiles will be preferably employed against armor; but if they are, their efficiency will not equal that of a. p. projectiles.

The trial is valuable, however, in showing the effect of such attack, and while the conditions do not admit of comparison of the plate with others, they show it to have been a good plate, combining elasticity and homogeneity. The majority of the Commission pronounced the plate "superior," and the minority "excellent." It is stated that the Commission considered these two plates as showing the best results ever attained at Gâvres, and that if such plates can be produced in the regular delivery of armor, a great advance has been made.

Very meagre details are at hand regarding the competitive tests, last February, of sample thin plates for rapid-firing gun shields. St. Etienne, St. Chamond, Le Creusot, and Marrel Brothers presented plates of 2¾ inches thickness, which were attacked by 65^{mm} chrome-steel projectiles weighing 8.8 pounds, fired with a velocity of 1,279 f. s., giving a striking energy of 100 tons per square inch, which is 17 per cent more than that just equal to the perforation of wrought-iron of the same thickness. Nine shots at each plate failed to perforate or show any appreciable difference in them. When tested with higher velocities, to determine that necessary to complete perforation, they were classed in the order named above. Their composition and processes of manufacture are not known.

As yet no contracts have been made with French manufacturers to supply nickel-steel armor for other than test purposes.

II.—ENGLISH TRIALS.

In its endeavors to determine the type of armor best suited for the protection of vessels to be built in the future, the British Admiralty has offered generous terms to manufacturers to supply test plates for trial under fixed conditions, such plates to be manufactured and treated in such manner as the manufacturer sees fit, the only conditions imposed being dependent on the showings of the plates under trial. The plates are to be 10½ inches in thickness and to be submitted to the "special plate test." In addition, manufacturers have been called upon to present, in competition with 10½-inch steel or compound plates for reception tests, nickel-steel plates of the same thickness. This latter call has been responded to in a very limited manner, and but few such plates, two in fact, have shown exceptionally good results.

The great compound-armor makers, with their large plants and skilled mechanics, are naturally making strenuous efforts to perfect their type; and in addition to the advantages thus accruing, new firms have come to the front in the competition, thus increasing the sources of the country's supply.

The one prominent point in the development of armor on which general opinion agrees, is the necessity of hardening the face to a degree equal, if possible, to that of the a. p. projectile by which it is attacked, in the endeavor to rupture the projectile at the instant of impact, and thus expend the striking energy on it instead of forcing the plate to do all the work in resistance to penetration and fracture. The inherent defect of untreated all-steel is recognized to be that of through-cracking; and that this is caused by its failure to break up the projectile at the instant of impact, before the resistence of the mass has succeeded in stopping its penetration, during which penetration the gripping action of the walls tends to hold the projectile intact, was well illustrated at Shoeburyness, where greater penetrations were accomplished in a hard-faced compound plate by adding a thickness of soft iron to the front face.

The greatest difficulty yet encountered in existing face-hardening processes appears to be the liability of the plate to warp, a defect that will be especially hard to overcome in dealing with curved plates. The two most prominent processes, those of Harvey and Tresidder, are described in full in the Notes on Ordnance, page 144, in addition to which are the lead-tempering process employed at St. Chamond, and special treatments employed by Vickers and Cammell.

In the following review of such of the year's trials in England as are at hand, it will be noticed that almost all of the plates have been treated for face-hardening. We will take them up by types, beginning with compound.

COMPOUND.

The two compound-armor manufacturers, Brown and Cammell, believing that by improved methods of manufacture, face-hardening treatment, and the employment of alloys, their type of armor can be made as effective against the attack of a. p. projectiles as it was against chilled-iron ones, have been producing special plates embodying either special treatments, or the employment of nickel in the face, or between face and back. The effects of their researches may be judged from the results of the trials.

BROWN.

The development of the Tresidder face-hardening treatment, employed by Brown, is shown by the following trials:

An ordinary 9-inch compound plate was cut into 8 blocks, 4 of which, untreated, are reported to have been of good quality, but not able to stop 6-inch a. p. projectiles with striking velocities of 1,830 f. s.

Block E was then Tresidderized, and block F oil-hardened, and the two submitted to trial as follows (see Pl. I):

Trial of Tresidderized and oil-hardened compound plates.

Dates of trials: March 3 and 6, 1891, at Shoeburyness.
Details of plates: 4 feet by 4 feet by 9 inches.

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectile, Hadfield, forged steel	pounds	100
Striking velocity (measured):		
Tresidderized	f. s.	1,824
Oil treated	f. s.	1,806
Striking energy:		
Tresidderized	f. t.	2,307
Oil treated	f. t.	2,261
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness:		
Tresiderized		1.43
Oil-hardened		1.41

The comparative results can readily be seen from the appearance of the fronts and backs of the plates. The conditions of the trial do not admit of comparisons with standard test plates, but it is simply valuable as showing the superiority of the Tresidder over the oil-hardening treatment, the latter not seeming to have increased the efficiency of the plate. The Tresidderized plate was warped with a convex face.

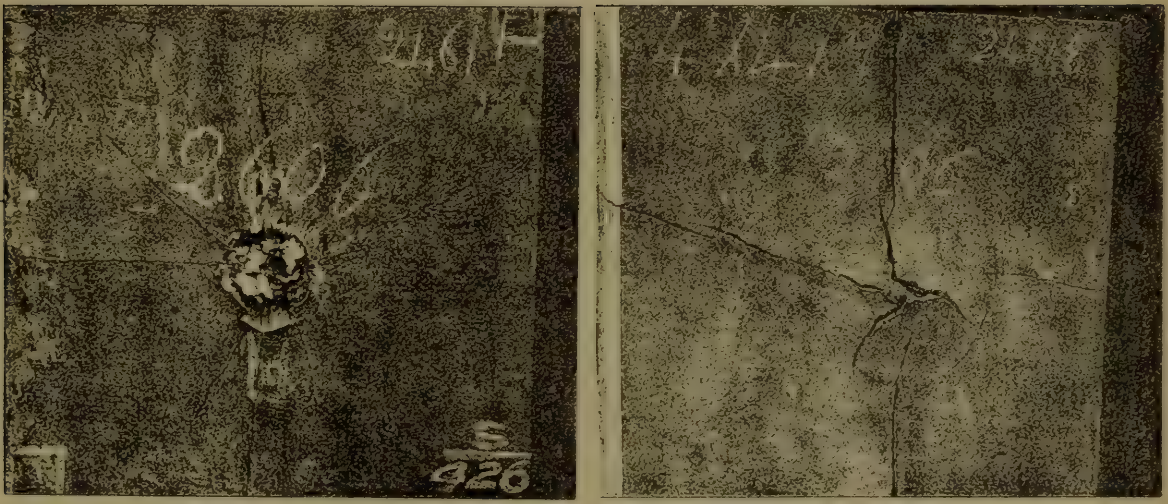
Block G was then oil-hardened, and block H Tresidderized and tested as follows: (See Pl. II, Fig. 1, in which through cracks are marked *t.*)

Trial of Tresidderized and oil-hardened compound plates.

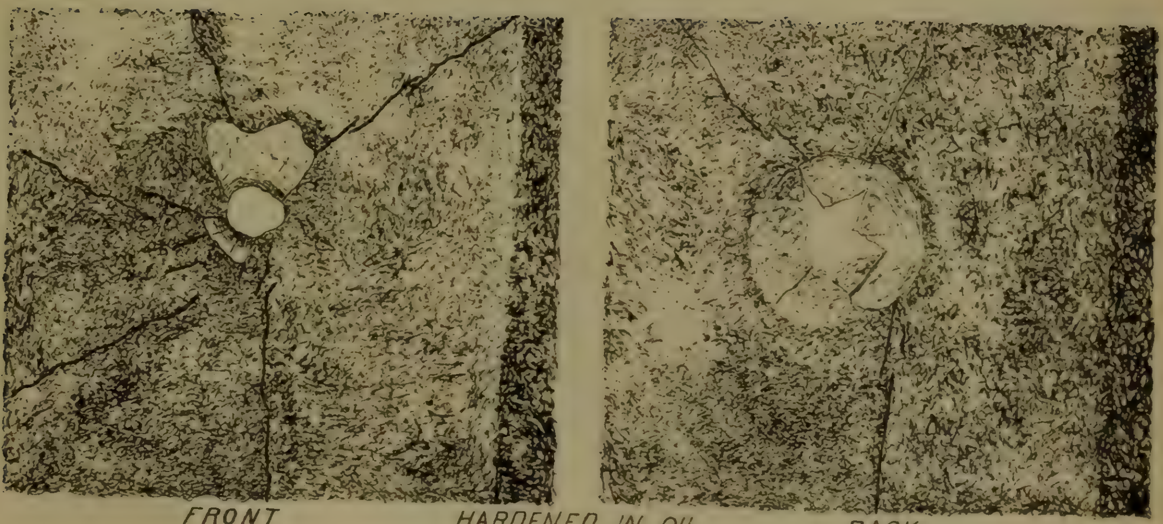
Date of trial: May 8, 1891, at Shoeburyness.
Details of plates: 4 feet by 4 feet by 9 inches. Weight of each plate about 2.57 tons.

BROWN COMPOUND PLATES PLATE I

MARCH 3 & 6 1891



FRONT TRESIDDER FACE HARDENED BACK

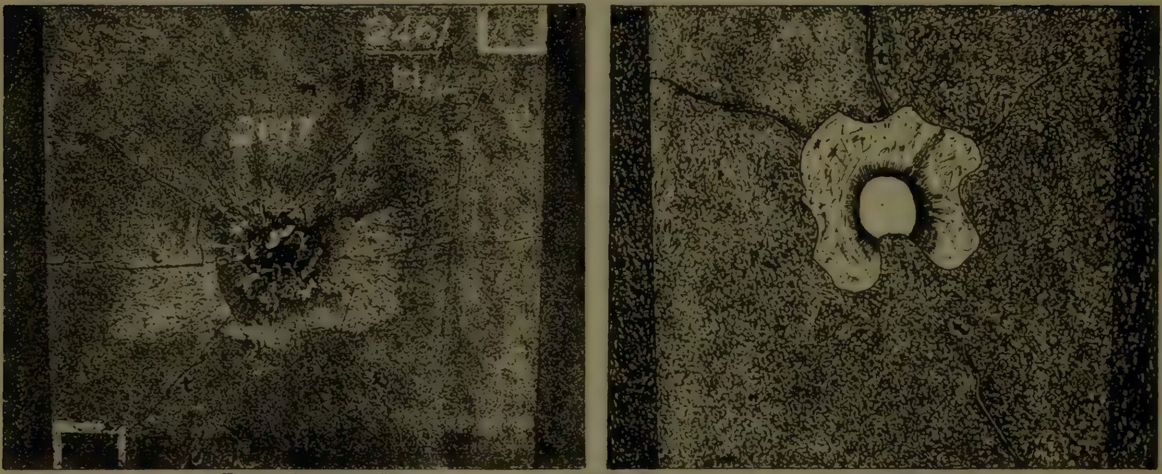


FRONT HARDENED IN OIL BACK

BROWN COMPOUND PLATES

PLATE II

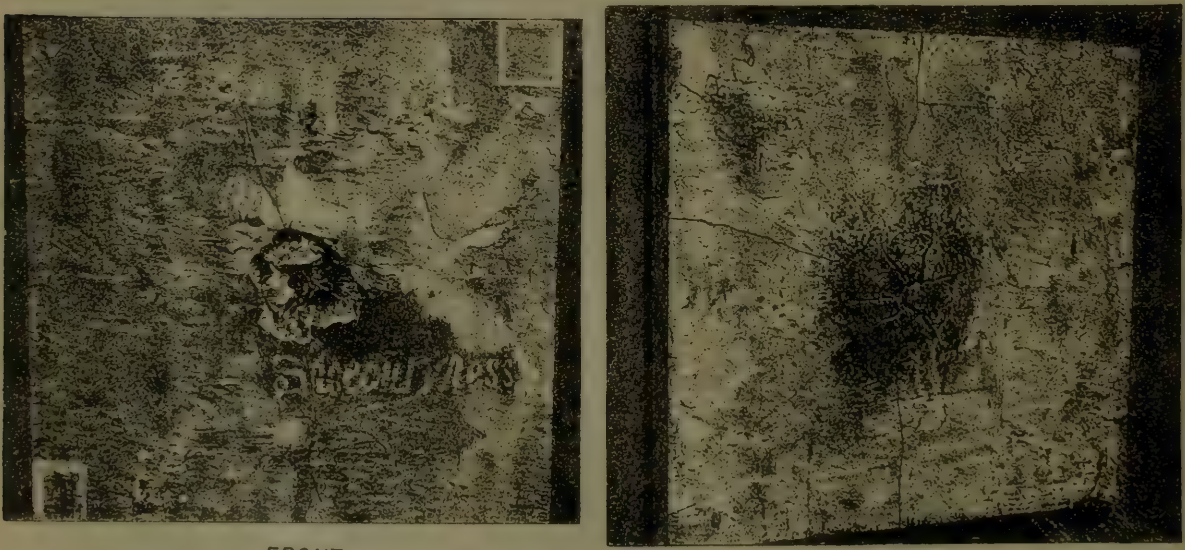
MAY 8 1891



TRESIDDERIZED FRONTS OIL HARDENED

BROWN TRESIDDER PLATE

JUNE 23 1891



FRONT

BACK

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectiles, Hadfield forged steel	pounds	100
Striking velocity (measured):		
Tresidderized	f. s.	1,868
Oil-hardened	f. s.	1,888
Striking energy:		
Tresidderized	f. t.	2,419
Oil-hardened	f. t.	2,470
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness:		
Tresidderized		1.50
Oil-hardened		1.53

In this trial the oil-treated plate was completely outmatched by the attack, which, with both plates, was much more severe than in the previous trials. The value of the Tresidder process is clearly demonstrated by the manner in which the Hadfield forged-steel projectile was broken up, it being recognized as possessing very superior a. p. qualities, although, perhaps, not up to the standard of Holtzers; and the progressive improvements in treatment are shown by the decreased amount of cracking, although the severity of the test was 7 per cent greater than that of the preceding trial. Another shot, fired at the corner of the plate, broke it off, as might have been expected.

The third small plate tested was of 10½ inches thickness, the conditions of the trial being as follows: (See Pl. II, Fig. 2.)

Trial of a Brown-Tresidder compound plate.

Date of trial: June 23, 1891 at Shoeburyness.
Details of plate: 4 feet by 4 feet by 10½ inches. Weight of plate about 3 tons.

Ballistical details.

[Gun 6-inch B. L. R.]

Projectile, Hadfield forged steel	lbs.	100
Striking velocity	f. s.	1,967
Striking energy	f. t.	2,684
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.34

This plate is stated in the public prints to have been badly honeycombed, and below the usual standard, and that it was therefore Tresidderized and used for Hadfield projectile reception tests. The attack for perforation was about as severe as that employed in the *Nettle* tests, had the projectile employed been of an equal standard, which is not believed to have been the case. The conditions of plate and projectile, however, being so different from those employed on board the *Nettle*, this trial is only of value in tracing the progress made in Tresidder's treatment; as such, it shows a falling off in comparison with the plate of May 8, the effect on the projectile and plate being about the same, while the severity of the attack was 16 per cent less.

The next trial of this series was of a plate which was cut from the top of a larger compound plate, and then treated by Tresidder's process. It is stated as being known to have been defective before the trial, and after shot No. 5, the weld showed a poor union of the face and back at that point. Its top was untrimmed. The details of this trial were as follows: (See Pl. III.)

Trial of a Brown-Tresidder compound plate.

Date of trial: July 23, 1891, at Shoeburyness.

Details of plate: 7 feet 6 inches by 7 feet 6 inches by 10½ inches, secured by eight bolts to 4 feet of oak backing.

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectiles:		
Hadfield's forged steel (first, third, and fifth shots)	pounds	100
Palliser chilled iron (second and fourth shots)	do	98
Striking velocities:		
Hadfield a. p. projectiles	f. s.	1949, 1909, 1937
Palliser chilled iron	f. s.	1929, 1939
Striking energies:		
Hadfield	f. t.	2634, 2527, 2602
Palliser	f. t.	2579, 2607
Striking energies of the three Hadfield projectiles as compared with that just necessary to perforate a plate of wrought iron of the same thickness		1.32, 1.26, 1.30

Firing details.

First shot: Projectile broke up. Penetration slight, with five fine cracks radiating to upper, lower, and right edges. No through cracks.

Second shot: Projectile splashed on face of plate. A few more fine cracks radiating to left and bottom edges and center of plate.

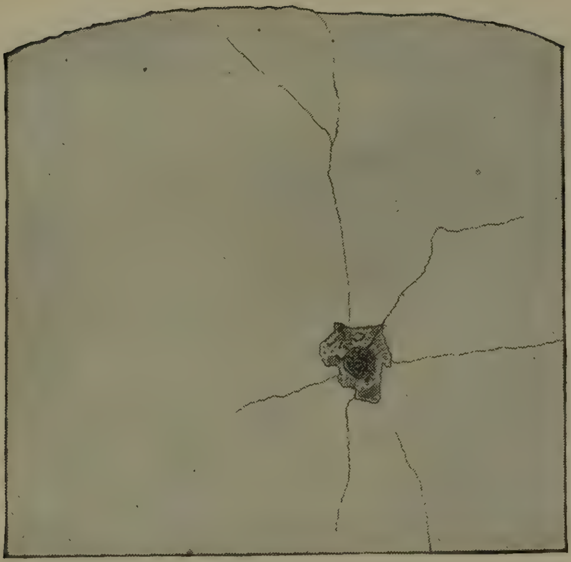
Third shot: Projectile broken. Fine crack joining shot No. 2, and a large piece of steel was splintered out towards the "slag end" of the plate.

Fourth shot: Projectile broke up, leaving its point in the plate. One crack extended to left edge of plate, where it was through. Fine cracks joining shots Nos. 2 and 3, and to upper edge of plate.

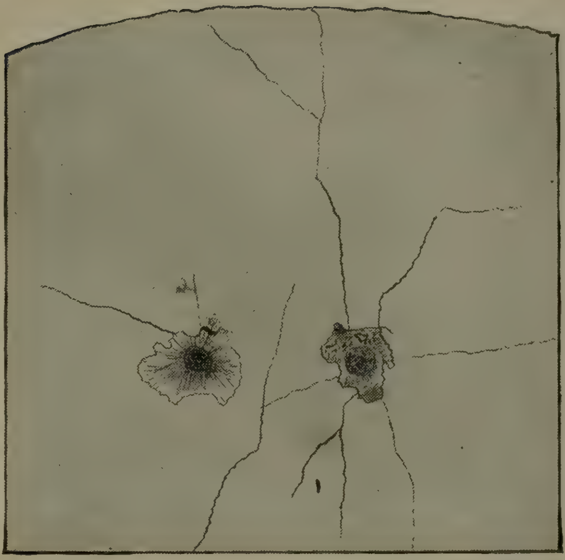
Fifth shot: Projectile struck between two cracks, splintering out the face up to them. Perforated plate and lodged in backing, base 16 inches from face of plate. Two through cracks at the edge of plate.

The face of the plate had warped convex 1½ inches, and the resulting space between its back and the backing was filled in solidly with Portland cement, an important precaution with compound armor where any "give" to the plate may prove disastrous to the weld and detach the hard steel face from its back. The first three shots were at the apexes of a triangle about the plate's centre, and the results were so favorable that two more shots were fired at the known to be weaker portion of the plate, resulting in a through crack and a complete perforation. The

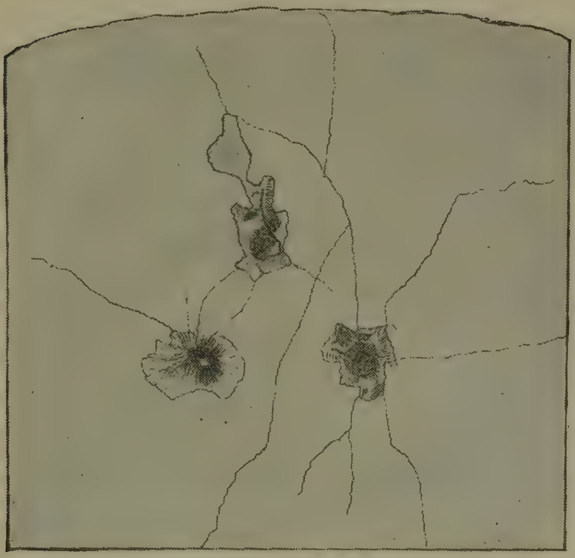
PLATE III.



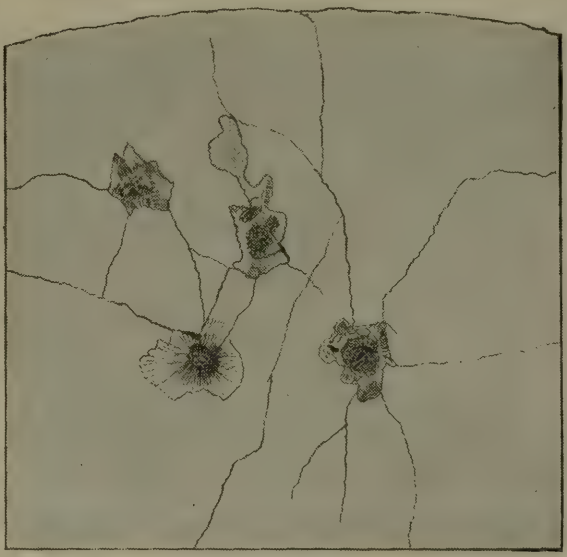
HADFIELD *a. p.* PROJECTILE.



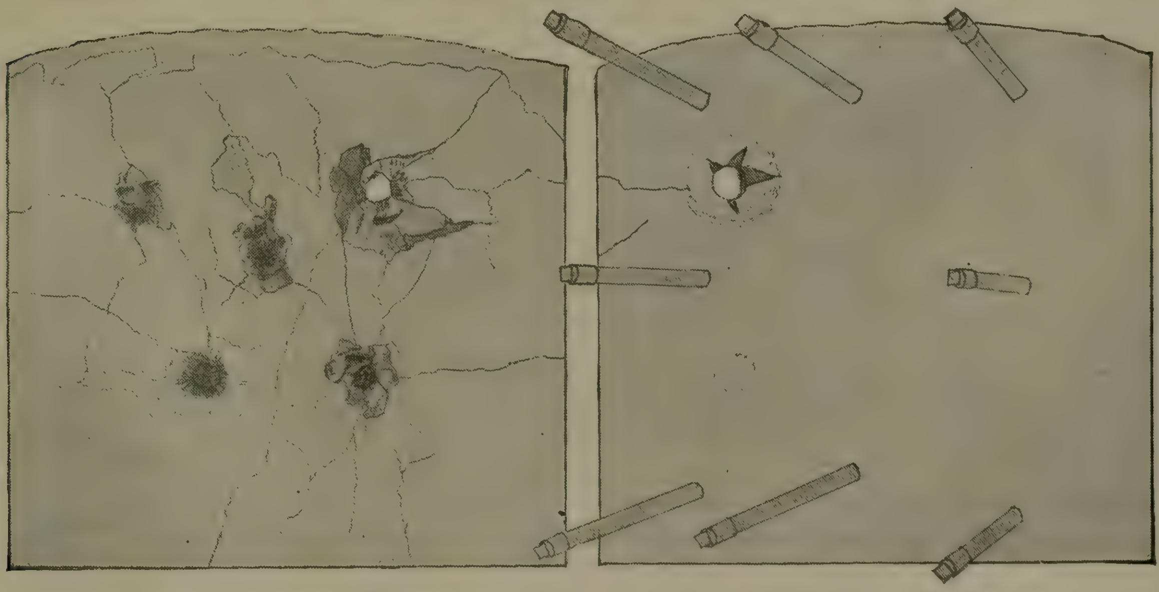
PALLISER PROJECTILE.



HADFIELD *a. p.* PROJECTILE.



PALLISER PROJECTILE.

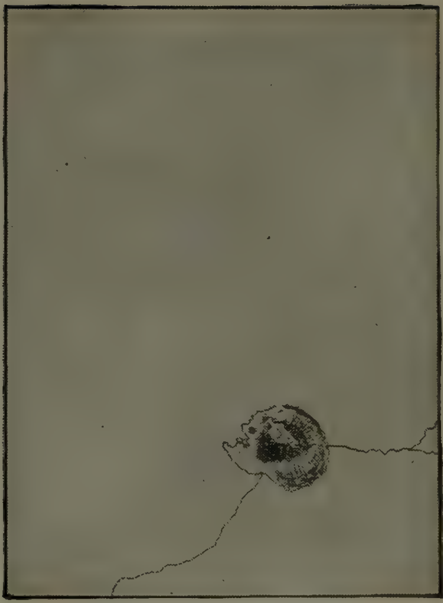


HADFIELD *a. p.* PROJECTILE.

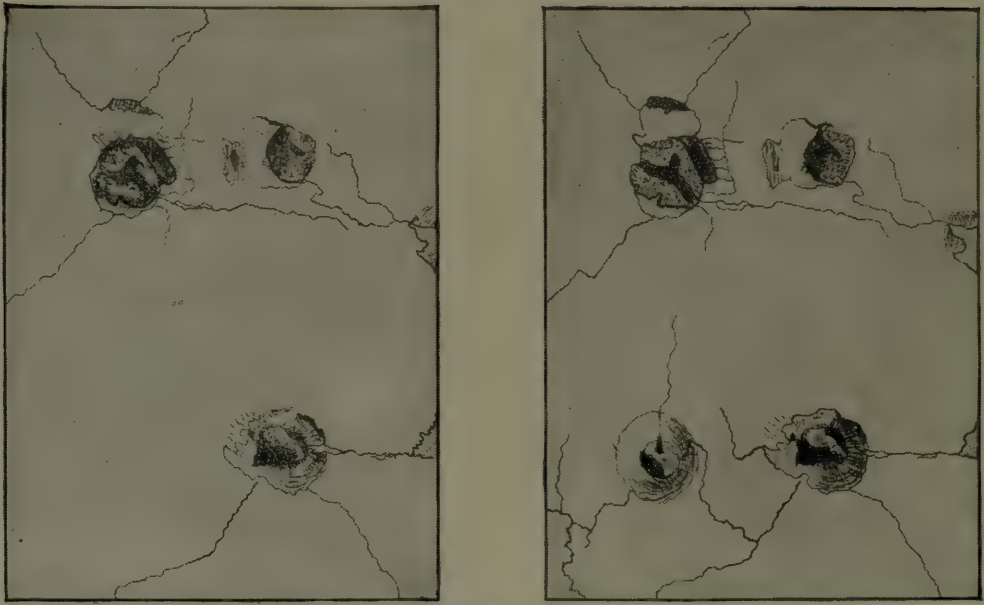
BACK OF PLATE.

BROWN-TRESIDDER PLATE (SHOEBURYNESS).

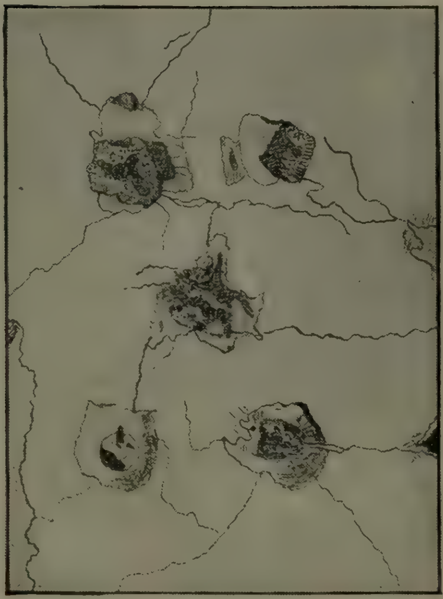
PLATE IV.



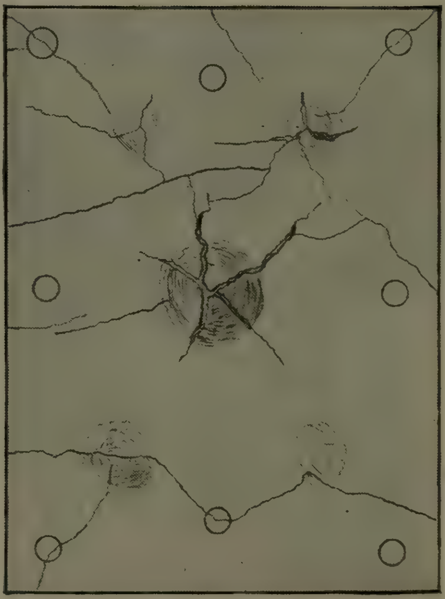
HOLTZER *a. p.* PROJECTILE.



PALLISER PROJECTILES.



HOLTZER *a. p.* PROJECTILE.



BACK OF PLATE.

BROWN-TRESIDDER PLATE. (NETTLE.)

severity of the attack was not great, and an unknown factor was present in the employment of Hadfield a. p. projectiles. The manner in which the first two of the projectiles were broken up, however, at the expense of only face cracks and very slight back bulges, speaks well for the Tresidder face-hardening treatment as applied to this plate. Shot No. 5 illustrates how fatal a defective weld is to compound armor, even when the face has been hardened to a high degree of efficiency.

This trial, being a private one, can not go on official record with the *Nettle* experiments, but is given, in connection with the preceding ones, as tracing the development of this face-hardening process, and as leading up to the first official trial of a compound plate with nickel-steel face so treated, which resulted as follows (see Plate IV):

Trial of a Brown-Tresidder compound plate.

Date of trial: October 2, 1891 on board the *Nettle.*

Details of plate: 8 feet by 6 feet by 10½ inches, secured by eight bolts to an oak backing 4 feet 6 inches thick and 5 feet 8 inches in center. Weight of plate about 9.4 tons.

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectiles:		
Holtzer a. p. (17⅝ inches long)	pounds	100
Palliser chilled cast-iron	do	98
Striking velocity	f. s.	1,976
Striking energy (Holtzer a. p. projectiles)	f. t.	2,723
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.35

Firing details.

First shot (Holtzer a. p. projectile).—Projectile broken into many fragments; point remained in plate. Splash 10 by 14 inches. Two fine through cracks, one to right edge, forming into two at the edge, and the other to bottom of plate. The back bulge was 0.4 inch high and 15¼ inches diameter. The back cracks were three in number, extending to right edge of plate and right and center lower bolt holes, which were cracked through.

Second shot (Holtzer a. p. projectile).—Projectile broken into many fragments; point remained in plate, front of core projecting 1 inch from face of plate. Face scaled off around point of impact 13 by 18 inches. Four through cracks radiating, one towards the center, another to the corner, and the others to the middle of the upper and left edges of the plate. Another crack developed from shot No. 1 to the corner of the plate. The back bulge was 0.9 inch high and 17.5 by 18.5 inches diameter. Small piece fell out of right edge of plate opposite shot No. 1.

Third shot (Palliser chilled cast-iron).—Projectile badly broken; head remained in plate, face scaled off 9 by 11 inches about point of impact. One through crack to right edge of plate; two face cracks, one joining the through crack, and the other, shot No. 2. Back bulge 0.6 inch high and 16 by 15 inches in size. A small piece fell out of right edge of plate.

Fourth shot (Palliser chilled cast-iron).—Projectile badly broken; head remained in plate. Splash of projectile 12 by 10 inches in size. Four radiating cracks, two of which extended to corner of plate and lower middle bolt and were through; one face crack about 2 feet long a few inches from left edge of plate; face crack from shot No. 1 extended along foot of plate to left. Back bulge 0.3 inch high and 13 inches in diameter.

Fifth shot (Holtzer a. p. projectile).—Projectile broken into small pieces; point remained in plate, end of projectile core projecting one half inch from face of plate. Breakage around impact 14½ by 18¾ inches. Small pieces of face broken off on bottom and left edges of plate. Seven cracks, six of which were through, either as cracks joining others or fissures. Back bulge 1 inch high and 18.5 by 17.5 inches in size.

The white appearance of the back of the plate would seem to indicate a similar use of Portland cement filling at the back as in the preceding trial. The resistance of the hardened nickel-steel face was apparent from the manner in which the Holtzers were shattered, the greatest penetration being about 5 inches. The upper half of the plate was slightly softer than the lower half, as shown by the penetrations and back bulges; the latter, however, were slight, the greatest, that of the fifth shot, being only 1 inch. Although holding together when removed from the backing, the plate was practically in ten pieces, which, however, would probably have been retained in place on a ship's side in a seaway with their own bolts, had they not been subjected to further punishment.

The results show a decided improvement over any of the trials of compound armor detailed in Chapter VI, No. X, and this is probably entirely due to the toughening and hardening of the face by employing an alloy of nickel and the .9 per cent carbon introduced by the Tresidder process. It is learned, however, that subsequent trials have failed to confirm the expectancies of the inventor of the Tresidder process, upon which so much hope was based after the trials above described.

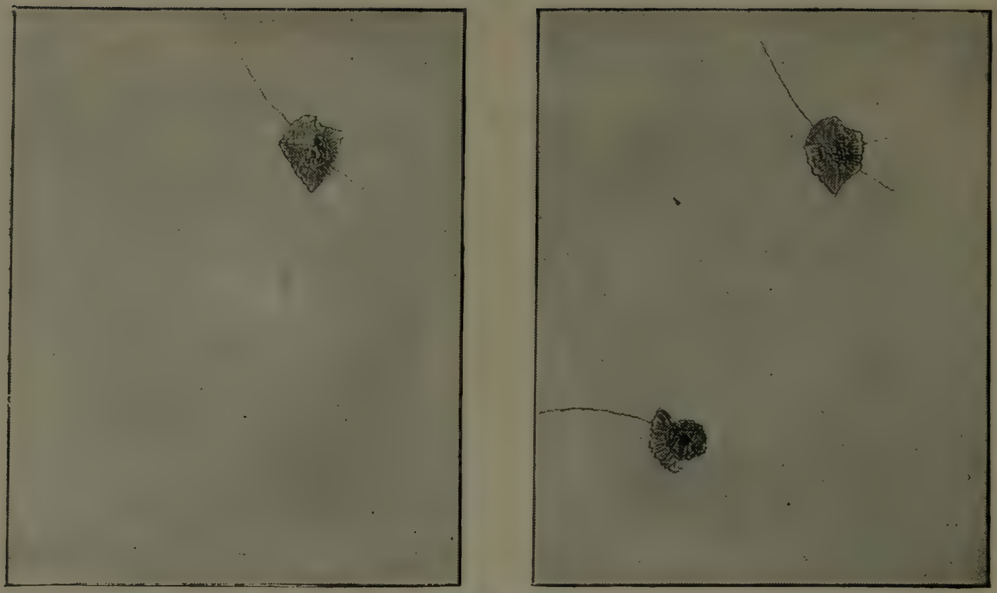
In addition to these experiments with the Tresidder face-hardening process, Brown & Co. have been investigating the employment of nickel-steel in compound armor, either between the steel face and iron back, or as a back to the plate, with the object of preventing through-cracking. As yet the results have been poor. One plate, subjected to private trial, October 9, 1891, was manufactured on the latter principle, the back being of mild steel containing 2 per cent nickel; but we find published in the *London Engineer* that although the weld was known to be imperfect, the results were not encouraging, the resistance being about what would be expected from an ordinary plate, while the back cracked more than a wrought-iron one would have. No mention is made of this plate having been Tresidderized.

As yet shown by official trials, the plate tested on board the *Nettle*, October 2, 1891, is the best exponent of compound armor manufactured by Brown.

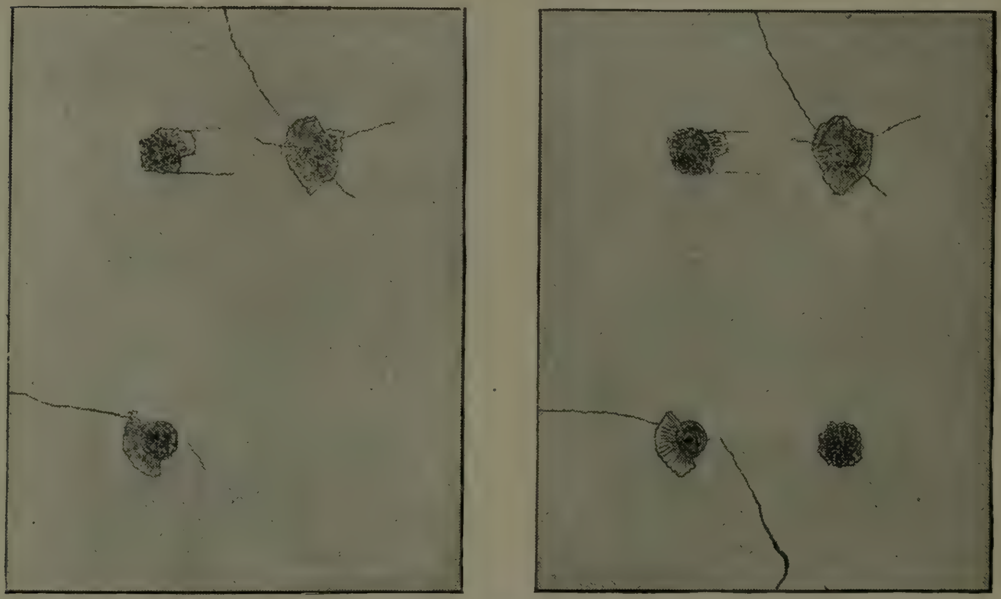
CAMMELL.

In the course of their researches, looking toward improvements in the manufacture of compound armor plates, Cammell & Co. have been

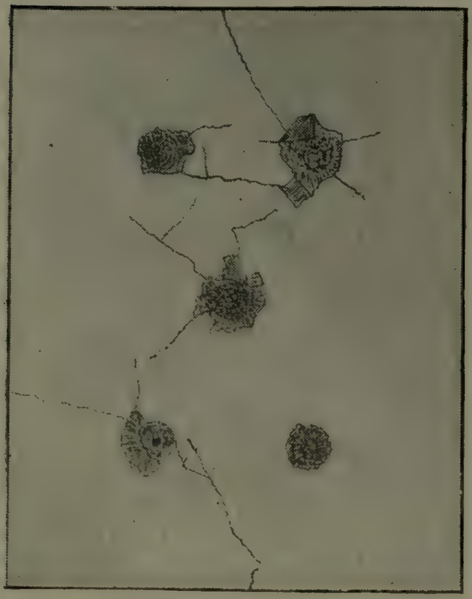
PLATE V.



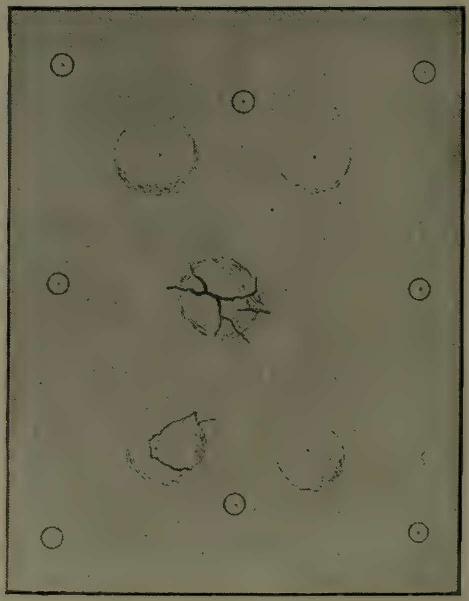
a. p. PROJECTILES.



PALLISER PROJECTILES.



a. p. PROJECTILE.



BACK OF PLATE.

CAMMELL COMPOUND PLATE.

conducting a series of private trials, the extent of which is apparent when it is noted that the following is the sixteenth plate tested, and which is presumed to have given the best results to date on account of the publicity given it. The conditions and results of the trial were as follows (see Plate v):

Trial of a Cammell compound plate.

Date of trial: August 27, 1891, at Elswick proving grounds at Riddesmouth.

Details of plate: 8 feet by 6 feet by 10½ inches, secured to backing by 8 bolts. (Wilson compound-plate, untreated.)

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectiles:		
Armor-piercing	pounds	100
Palliser chilled cast-iron	do	100
Striking velocity (measured):		
Armor piercing	f. s.	1966, 1956, 1972
Pallisers	f. s.	1974, 1974
Striking energies:		
Armor piercing	f. t.	2680, 2655, 2696
Pallisers	f. t.	2702
Striking energies of armor-piercing projectiles compared with that just necessary to perforate a wrought-iron plate of the same thickness		1. 34, 1. 33, 1. 35

Firing details.

First shot: (a. p. projectile).—Projectile broke up; head remained in plate; slight scaling of face around point of impact; three hair cracks in face, one extending to top of plate and the other to right edge.

Second shot: (a. p. projectile).—Projectile broke up; head remained in plate; slight scaling of face; one hair face crack extending to left edge of plate.

Third shot: (Palliser chilled cast-iron).—Projectile badly broken; head remained in plate; two face cracks extending toward shot No. 1.

Fourth shot: (Palliser chilled cast-iron).—Projectile badly broken; point remained in plate; widened crack from second shot to lower edge of plate.

Fifth shot: (a. p. projectile).—Projectile broken; head remained in plate; slight scaling around point of impact; three irregular face cracks, extending to first, second, and third shot holes; steel face loosened between first and third shots; star-shaped fissure in back bulge.

The heights of the back bulges are not known, but are apparently very slight. This plate was not face-hardened, neither did it contain nickel. Its merits are considered to be due entirely to improvements in manufacture of compound armor. It is regretted that this trial was not held under *Nettle* conditions with Holtzer a. p. projectiles, and that the penetrations and dimensions of back bulges are not known, so as to admit of exact comparison with other official trials. The severity of attack was almost equal to that of the *Nettle* trials, but there still remains a doubtful quantity in the quality of the projectiles employed. The steel face apparently resisted penetration well, but at the expense of numerous face cracks and scaling around shot hole No. 1. The fifth shot also loosened the face between shots Nos. 1 and 3. The back held up to its work well and resisted all through cracking, except the fissures on the bulges of the third and fifth shots.

Although this trial was not official, and different projectiles were used than with the Brown-Tresidder plate, tested October 2, 1891, a comparison of the two tests seems to us to result decidedly in favor of this Cammell plate. The punishment inflicted by the two Palliser projectiles was less than that on the Brown plate, and that by the a. p. projectiles was also less, while the projectiles used against the Cammell plate appear to have behaved about as well as the Holtzers. It is not believed that the possibly greater amount of energy required to break up the Holtzers, over that required by the other a. p. projectiles, would be sufficient to account for the through cracking of the Brown plate. The attacks of the Pallisers show for themselves.

Since the date of the Riddesmouth trial, other compound plates, embodying supposed improvements in treatment and composition, have been manufactured by Cammell & Co.; but, as yet, all processes for hardening which could be applied to the armor of a vessel have proved unsuccessful in England. Special plates, such as the ones cited above, have been produced to give superior results to similar plates untreated, but the production of such armor has been limited to these isolated cases.

Cammell's experiments with compound plates in which nickel-steel is employed in the face have resulted in failures, and, as developed to date, we consider the best exponent of the compound type of armor to be the Cammell plate tested at Riddesmouth August 27, 1891.

NICKEL STEEL.

In response to the Admiralty's call for nickel-steel plates, Cammell, Brown, Vickers, Jessops, Beardmore, and the Nickel-Steel Syndicate have manufactured and presented for trial, test plates; but these have mostly been limited in thickness to 4 inches for the so-called "deck-armor test."

The conditions under which they were tried were as follows:

Gun, 5-inch B. L. R.		
Projectile, Palliser chilled cast-iron	pounds	49
Charge, S. P. powder	do	8
Striking velocity	f. s.	1,200
Striking energy	f. t.	499
Range	ft.	30
Three shots at apexes of a triangle, sides	inches	21½
Dimensions of plates		4 feet by 4 feet by 4 inches.
Plate supported by 6 shores, backing 9 feet away from plate.		
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.24

The degree of efficiency which has been attained by these plates may be judged from four of the several plates that have been submitted to the above test, and are shown on Plate VI.

PLATE VI.

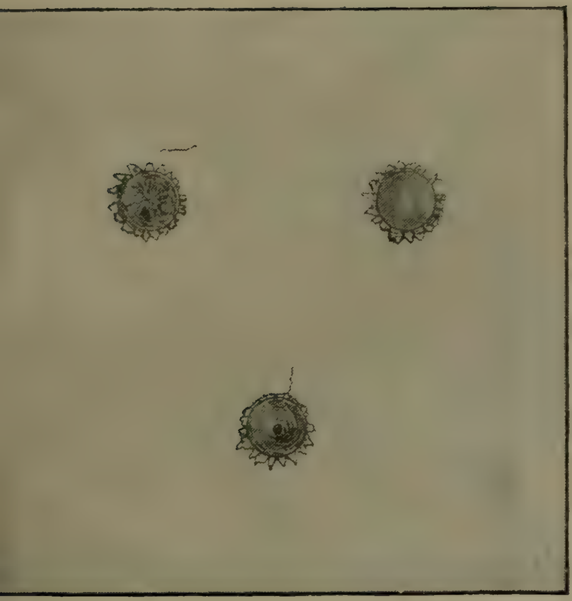


Fig. 1.

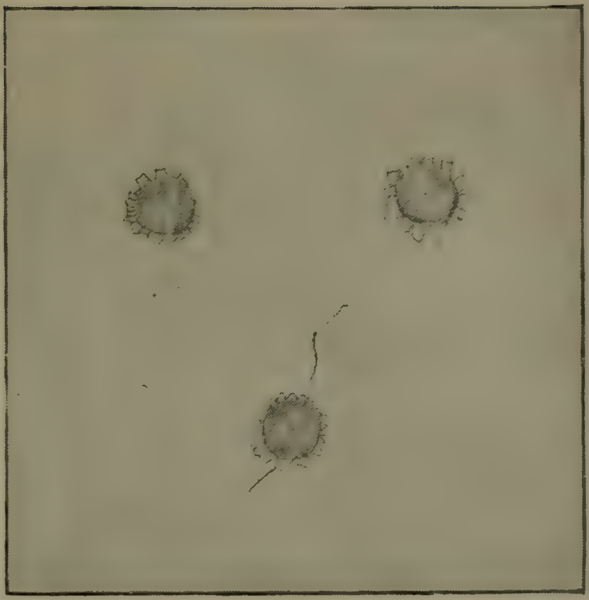


Fig. 2.

CAMMELL.

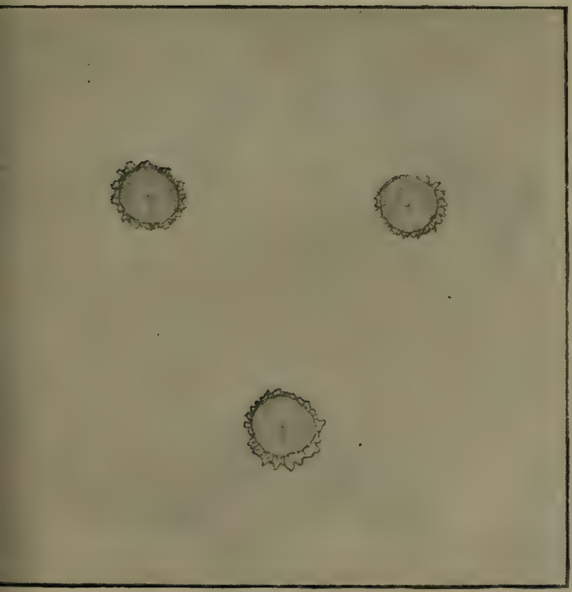


Fig. 3.

BROWN.

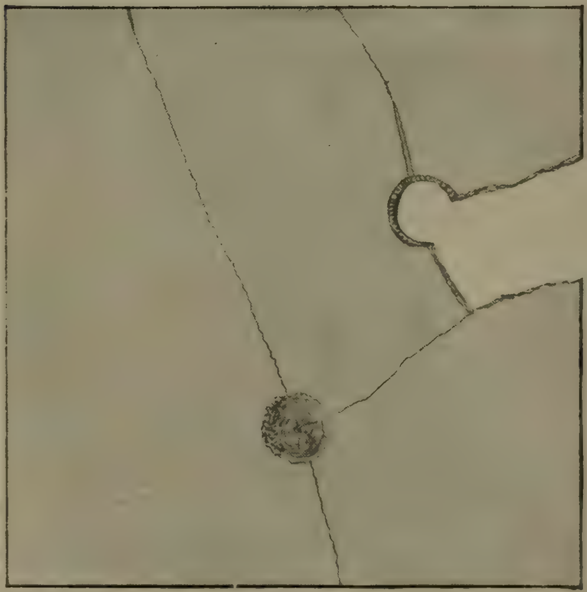
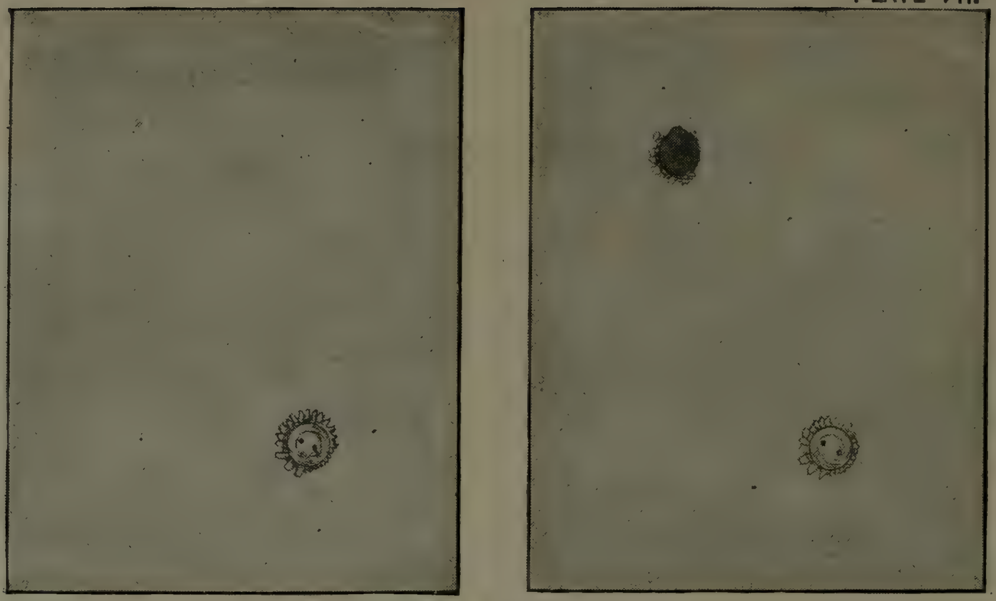


Fig. 4.

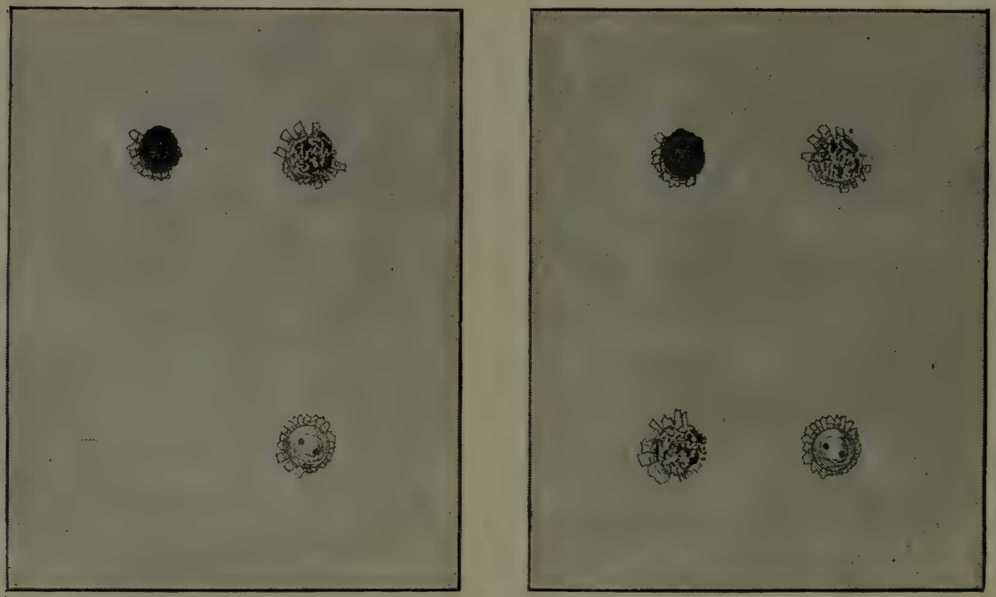
VICKERS.

4-INCH NICKEL-STEEL PLATES.

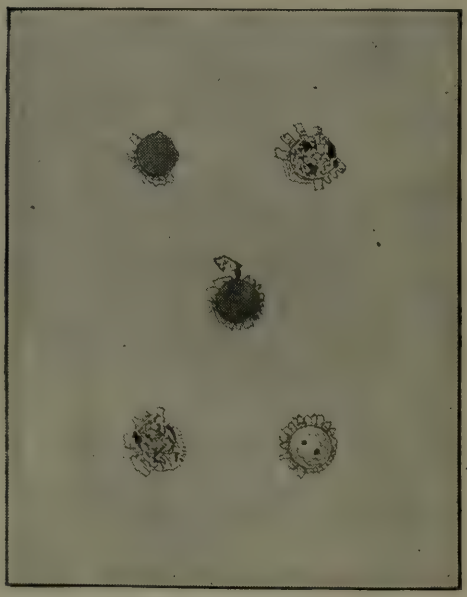
PLATE VII.



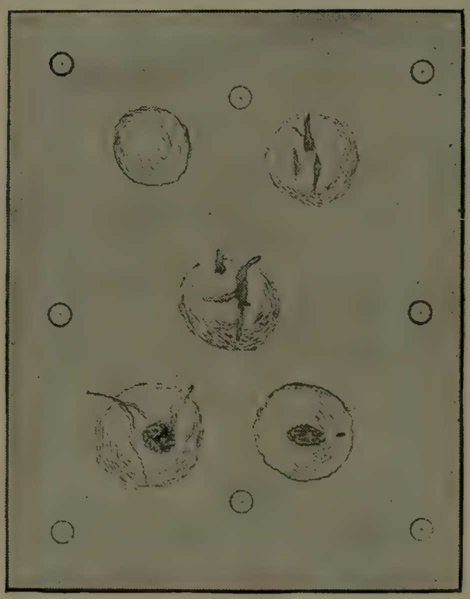
HOLTZER *a. p.* PROJECTILES.



PALLISER PROJECTILES.



HOLTZER *a. p.* PROJECTILE.



BACK OF PLATE.

CAMMELL'S NICKEL-STEEL PLATE (DECEMBER 9, 1891.)

Both of the Cammell plates (Figs. 1 and 2) showed good results, the greatest penetration in Fig. 1 being 5.8 inches with a back bulge of 2.1 inches; the Brown plate shows good resistance also. The Vickers plate was not up to the standard of the others; for although the first shot only penetrated 6½ inches, producing two slight cracks, the second shot, although broken, lodged its point in the backing 9 feet away, and broke off the corner of the plate. A third shot would probably have completely wrecked the plate. Fig. 2 shows a Cammell plate tested for reception in September, 1891, at which trial we find plates, presented by other makers, recorded as "fairly good," "not good," or "not satisfactory."

The general results, however, have led the Admiralty to adopt nickel-steel armor for the superstructures of six of the eight new battle-ships building, the steel armor for the other two, *Royal Sovereign* and *Hood*, having been contracted for before 4-inch nickel-steel was perfected. The nickel-steel "deck-armor plates" of at least two firms are all being accepted.

The available data on hand of nickel-steel plates of 10½ inches thickness is confined to the production of two manufacturers, Cammell and Vickers, who have, as yet, only produced special plates for Admiralty test, no such armor having been contracted for for any vessel building. These trials having all been conducted on board the *Nettle*, under fixed conditions, admit of ready comparison.

They are detailed here in the order of dates of trial:

Trial of a Cammell nickel-steel plate. (See Plate VII).

Date of trial: December 9, 1891, on board *Nettle*.

Details of plate: 8 feet by 6 feet by 10½ inches, secured by eight bolts to an oak backing 4 feet 6 inches thick at top and bottom, and 5 feet 8 inches thick in centre.

Ballistical details.

[Gun used, 6-inch B. L. R.]

Projectile:		
Holtzer a. p. forged steel	pounds	100
Palliser chilled cast-iron	do	98
Striking velocity	f. s.	1,976
Striking energy (Holtzer a. p. projectile)	f. t.	2,723
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.35

Firing details.

First shot: (Holtzer a. p. projectile)—Projectile penetrated 14.25 inches and remained in plate apparently intact, point projecting 3.75 inches at back of plate, and base 3.25 inches from face of plate. Front bulge 1.25 inches high, and back bulge 4 inches high and 14.25 by 14.5 inches in size. No cracks. Four fissures in back of bulge. Backing indented 4 inches.

Second shot: (Holtzer a. p. projectile)—Projectile penetrated 12 inches and rebounded, broken into several pieces; point rebounded 15 feet, and base to front of battery (30 feet); body broken. Front bulge 1 inch high; back bulge 3 inches high and 14.25 by 14.5 inches in size. No cracks; four fissures in back of bulge. Backing indented 2.5 inches.

Third shot: (Palliser chilled cast-iron projectile)—Projectile broken up badly, point remaining in hole. Front bulge, 1.5 inches; back bulge, 0.75 inch high, and 14.25 inches diameter. No cracks or fissures. Backing indented 0.5 inch.

Fourth shot: (Palliser chilled cast-iron projectile)—Same as round No. 3, except that the front bulge was 1.25 inches high, and the back bulge 0.8 inches. Backing indented 0.7 inch.

Fifth shot: (Holtzer a. .p. projectile)—Projectile penetrated 13.25 inches, and rebounded to bulkhead (30 feet) intact. Front bulge, 2 inches high; and back bulge 3 inches high and 14.25 inches diameter. No cracks. Four fissures in back bulge. Backing indented 2.75 inches.

This plate was treated for face-hardening by a special process, and is thought to have contained a moderately high percentage of both carbon and nickel. The results give an excellent showing for tenacity and homogeneity, no cracks being developed excepting the fissures of the back bulges. A lack of hardness is apparent in the face, resulting in considerable penetrations and back bulges, the latter being quite noticeable even with the Pallisers. From all appearances, however, the plate after the trial was in a condition to afford ample protection to still further similar attack. This was the first successful 10½-inch nickel-steel plate manufactured by Cammell.

This trial was followed by that of another Cammell plate in January, the results of which were as follows:

Trial of a Cammell nickel-steel plate. (See Plate VIII.)

Date of trial.—January 12, 1892, on board *Nettle.*

Details of plate and *ballistical details;* same as in preceding trial.

Firing details.

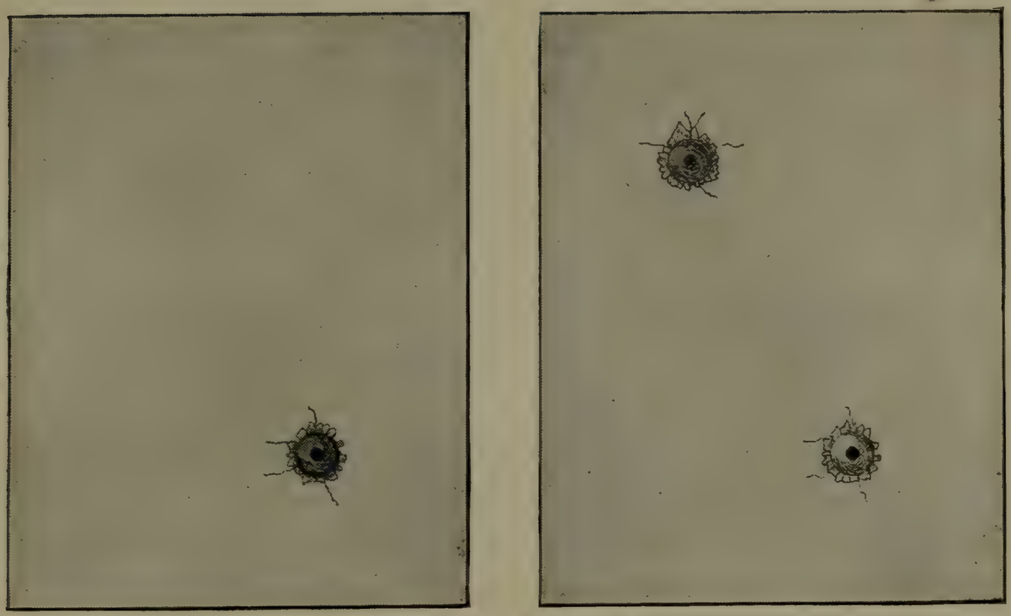
First shot (Holtzer a. p. projectile).—Projectile penetrated 10.25 inches and broke up; point remained in plate; depth from broken part to face of plate, 1.4 inches; base of projectile, 7.5 inches in length, rebounded 29 feet. Front bulge, 1¼ inches high; back bulge, 3 inches high, and 14.5 by 15.25 inches in size. Seven slight fissures around front of hole, and eight fissures and curved crack around back bulge. Two small pieces of back bulge broke off and remained in plate. Indent, 3.25 inches.

Second shot (Holtzer a. p. projectile).—Projectile penetrated 10.5 inches and broke up; point remained in plate; depth from broken part to face of plate, 2.3 inches; base rebounded 36 feet. Fringe, 1¼ inches high, and back bulge 3.25 inches high, and 16 by 18 inches in size. Eight small fissures around front of hole, and a small piece of the face broken off. Five fissures in back bulge, and a crack 15 inches long around the bottom of the bulge. Point of projectile flush with rear face of plate, and small piece of the bulge broken off remaining in the backing. Indent, 3.5 inches.

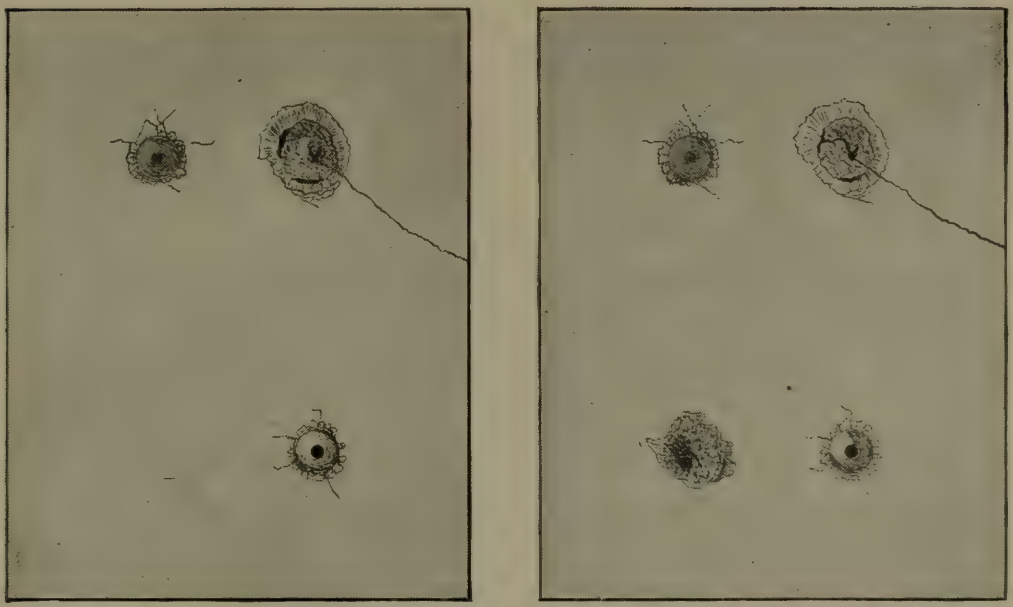
Third shot (Palliser chilled cast-iron).—Projectile badly broken; point remaining in plate. Face of plate scaled off 13 by 14.75 inches. One through crack to right edge of plate, 0.5 inch wide at its bottom. Fringe, 1.25 inch high; back bulge, 0.4 inch high and 15 inches in diameter. Right and lower edge of bulge cracked, joining crack mentioned above. Indent, 0.4 inch.

Fourth shot (Palliser chilled cast-iron).—Projectile badly broken; point remained in plate. Face of plate scaled off 12 by 12 inches. Fringe, 1.75 inch high; back bulge, 0.4 inch high and 14 inches in diameter. Small crack in center of bulge, with four fissures running from it. Indent, 0.4 inch.

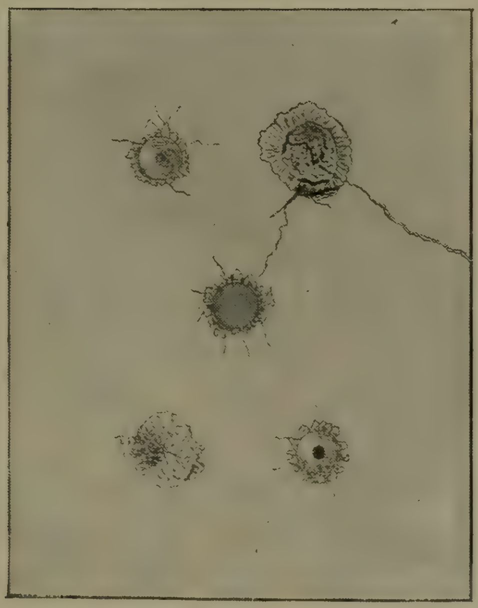
PLATE VIII.



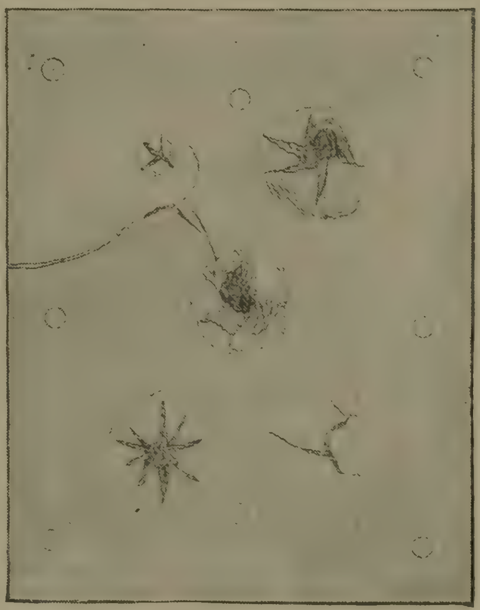
HOLTZER *a. p.* PROJECTILES.



PALLISER PROJECTILES.



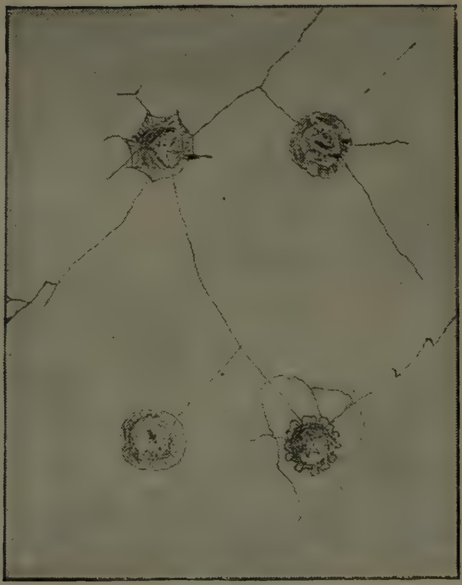
HOLTZER *a. p.* PROJECTILE.



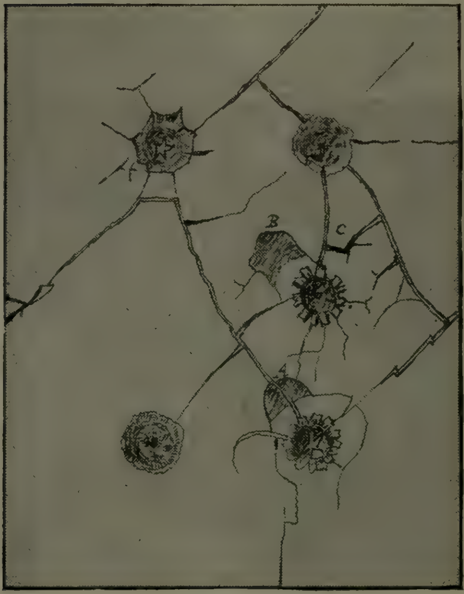
BACK OF PLATE.

CAMMELL'S NICKEL-STEEL PLATE (JANUARY 12, 1892.)

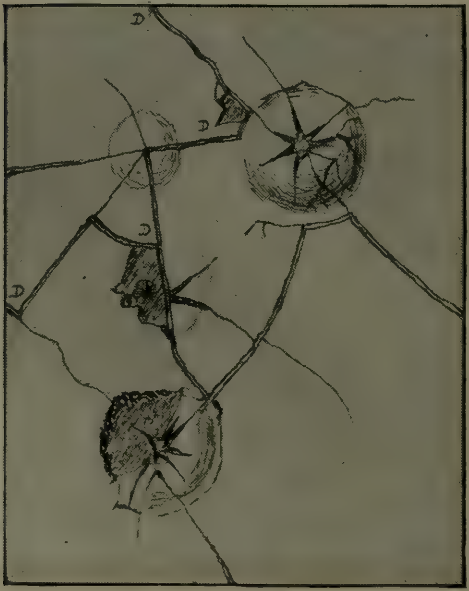
PLATE IX.



FOURTH SHOT.



FIFTH SHOT.



BACK OF PLATE.

VICKER'S NICKEL-STEEL PLATE.

Fifth shot (Holtzer a. p. projectile).—Projectile penetrated 12.25 inches and rebounded in five pieces. Fringe, 1 inch high; small piece of face broken off. One through crack from hole to No. 3 shot; nine small fissures around hole. Back bulges 1.75 inches high, and 15 by 16 inches in size. Three pieces of plate broken away, one remaining in backing. Size of hole at back, 2 by 2.75 inches. Indent, 2 inches.

This plate, like that tested December 9, 1891, was manufactured for the "Admiralty special test," and being tested at a later date is taken as involving attempted improvements in manufacture. That such have been accomplished in the face-hardening is evident from the manner in which the Holtzers were broken up, the loss of energy expended on them being apparent in the 2 inches less penetration and two-thirds of an inch less height of back bulges. The effect of the face hardness is also shown by the attack of the Pallisers, the back bulges being about half those of the preceding trial; but the rending effect of the upsetting brittle projectile in the third round proved the plate to be deficient in tenacity, the cracks developed at the third and fifth rounds indicating more the action of an all-steel plate. This plate has the appearance of being of a higher grade of steel, but involving less nickel than the preceding one, a little more of which might possibly have prevented the through cracking.

These two plates show Cammell's ability to manufacture nickel-steel armor of excellent quality, and, all things considered, we are inclined to regard the plate tested January 12, 1892, as the better; the penetrations and back bulges being less, the damage to the projectiles more severe, and the cracking not being so excessive as to endanger the parts being dislodged from a ship's side under service conditions.

The last nickel-steel plate presented for "special test" was that of Vickers, the data of which trial were as follows: (See Plate IX).

Trial of a Vickers nickel-steel plate.

Date of trial: January 29, 1892, on board the *Nettle*.
Details of plate and *ballistical details*, same as in the preceding trial.

Firing details.

First shot (Holtzer a. p. projectile).—Projectile penetrated 11.3 inches and rebounded broken; body rebounded 12 feet; point lost. Fringe 1¾ inches high. One through crack extending to right edge of plate, and several small cracks around hole. Five fissures in back bulge.

Second shot (Holtzer a. p. projectile).—Projectile penetrated 11.1 inches and rebounded split up. Slight scaling and several small cracks around hole; three through cracks—one to shot No. 1, one to upper edge, and one to left edge of plate. Six fissures and several cracks in back bulge.

Third shot (Palliser chilled cast-iron).—Projectile broken, head remaining in plate. Slight scaling around hole, and four fine radiating cracks.

Fourth shot (Palliser chilled cast-iron).—Projectile broken, head remaining in plate. Breakage across penetration, 11 inches in diameter. One crack joining previous crack connecting shots Nos. 1 and 2.

Fifth shot (Holtzer a. p. projectile).—Point of impact at centre of largest uncracked surface. Projectile broken, head remaining in plate. Regular fringe around hole, 1¼ inch high. Through cracks joining shots Nos. 1, 3, and 4, and several fine surface cracks. Former cracks opened to one-quarter to five-eighths of an inch. Scaling off of face pieces at A and B. Part at C projects 1¼ inch. Corner marked D broken off.

The plate stopped all projectiles, but at the expense of numerous through cracks and large back bulges. The fifth shot was fired at the largest uncracked surface, thus giving the plate all possible advantage. The action of the plate was very similar to that of the 4-inch nickel-steel plate of Vickers, tested April 8, 1891 (see Plate VI), and they both indicate the employment of a very high grade of steel and an imperfect development of the use of nickel alloy.

These three plates represent the best nickel-steel armor productions of the year in England; and summing up, we find several firms able to supply it of 4 inches thickness, but only two that have succeeded in manufacturing it of greater thickness. Of these, one has failed to produce an exceptionally good plate, and of those presented by the other, we find the Cammell 10½-inch plate, tested January 12, 1892, as the best exponent of the type yet produced.

THE BEST ENGLISH ARMOR PLATE OF THE YEAR.

In comparing the best results attained in England during the year with nickel-steel and compound armor, the two plates which, strictly speaking, should be discussed are the Cammell nickel-steel plate, tested January 12, 1892, and the Brown-Tresidder compound plate, tested October 2, 1891, both having been *officially* tested on the board the *Nettle* under similar conditions.

The results show decidedly in favor of the hard faced compound plate in resistance to penetration and back bulging, but the damage to the face and through cracking was very much less in the nickel-steel plate. As the plates stood at the end of the trials, both had resisted perforation, and both were entirely held in place by their bolts. Further attack on each plate would probably have been more disastrous to the compound plate through the breaking away of portions by its excessive cracking; whereas, had the original attack been more severe, perforation would have resulted first in the nickel-steel plate. Through-cracking, *when not excessive*, is preferable to perforation in the protection a plate affords to materiel and personnel behind it, but in this case it is questionable whether the through-cracking was excessive. Had the nickel-steel plate been perforated only once, we would have been led to decide in favor of the Brown-Tresidder plate, but as it succeeded in keeping out all projectiles, and was in better condition to resist further similar attack at the end of the trial, we are rather inclined to place it ahead of the Brown-Tresidder plate in order of merit.

Although the test of the Cammell compound plate was an unofficial one, and the extent of the penetrations and back bulges is not known, the excellent showing of the plate can not be ignored. From its appearance the penetrations and back bulges seem no greater than those of the Brown-Tresidder plate, while the cracks were fewer and all confined to the face, the back only showing fissures on two of the bulges. Even considering that Holtzers were used against the nickel-steel plate, and a. p. projectiles of a different quality against the compound one, the severity of attack was nearly the same in both cases; and, plate for plate, the compound one makes the better showing after trial, both as to resistance to penetration and to through cracking.

It can not be assumed, however, that because the best experimental plate of the year is a compound one, that that *type* of armor is the best one extant. It must be remembered that this plate is the result of years of experience of a firm that has been producing large quantities of compound armor; that they have recently been conducting numerous private trials looking toward the development of their type, of which this, the sixteenth plate, gave the best results; that this is the best compound plate ever tested; and that in the past ten months they have not shown another compound plate equaling it. On the other hand, the production of nickel-steel armor of 10½ inches thickness is a new industry in England, and this plate is only the second one that has proved successful on trial, both being the production of the same maker, who is a known advocate of the compound type. The case is a peculiar one; that of a firm experienced in, and provided with a complete plant for, producing compound armor, competing against itself in a new industry; and while the results of the year show that they have evidently become possessed of the secret of producing nickel-steel armor of a good degree of efficiency, it also shows that they have not yet reached as high a standard with it as they have, from their long experience, with the compound type.

The evident cause of the superiority of the compound plate lay in its greater face hardness, and as there is no apparent reason why a nickel-steel plate should not be as efficiently treated for this quality by the Tresidder or other process as a compound plate, it is believed that had this plate, tested January 12, 1892, been treated as was the Brown-Tresidder, tested October 2, 1891, much superior results would have been attained with it. This opinion is substantiated by the results of the trials at Indian Head.

III.—UNITED STATES TRIALS.

In order to determine the best type of armor to employ on board the vessels of war in course of construction, the Navy Department had manufactured eight plates, all being of steel of various grades, and each being face-hardened, or containing an alloy of nickel, or both; these were subjected to competitive trials at the Indian Head proving grounds during the past year.

The dimensions of each plate were 8 feet by 6 feet by 10½ inches, except in the cases specially noted; and with one exception, also noted, each plate was secured to an oak backing, 3 feet thick, by twelve bolts 2.36 inches in diameter, giving a total bolt cross section of 52.29 square inches.

Three of the plates submitted for the test were made by the Bethlehem Iron Company, and five by Carnegie, Phipps & Co., of Pittsburg, the essential difference in whose treatments is that the former employs a steam hammer for reducing the ingot, while this is effected at the latter establishment by the use of rolls.

The firings took place on three different dates, October 31 and November 14, 1891, and January 13, 1892, but as all of the plates were manufactured at practically the same time, they will be discussed in the following pages in their reverse order of merit, and will be referred to in that order.

The plate, ballistical, and firing details herein contained are taken from the report of the Board, and were as follows:

Plate details.

Date of trial.	Character of plate.	Maker.	Weight.	Total bolt cross section per ton of plate.
			Pounds.	*Sq. inches.*
Oct. 31, 1891	High-carbon nickel-steel	Bethlehem Iron Company	20, 494	5. 71
Do	Low-carbon nickel-steel	Carnegie, Phipps & Co	20, 844	5. 62
Do	Low-carbon steel, Harvey	Bethlehem Iron Company	20, 506	5. 71
Nov. 14, 1891	High-carbon nickel-steel	Carnegie, Phipps & Co	20, 590	5. 69
Do	Low-carbon nickel-steel, Harvey	do	20, 220	5. 79
Do	High-carbon nickel-steel, Harvey	Bethlehem Iron Company	20, 682	5. 66
Jan. 13, 1892	Low-carbon steel, Harvey	Carnegie, Phipps & Co	19, 400	6. 04
Do	High-carbon nickel-steel, Harvey	do	15, 930	4. 90

The targets were set up so that the muzzle of the 6-inch B. L. R. was 57.5 feet, and the 8-inch B. L. R. 55.5 feet, from the face of the plate when the gun was pointed at its centre, the axis of the gun being then perpendicular to the plane of the plate.

The backing was constructed in accordance with the drawings furnished by the Bureau of Ordnance, except that, on account of the length of the armor bolts, on the first day wooden and on the second iron washers were used under the cup washers of these bolts. During the first day's firing some of the wooden washers were split and somewhat compressed and the armor-plate bolt nuts were in some cases tightened between the shots.

The surfaces of the plates were as they came from the makers and were free from paint.

The firing programme was as follows, except in one case specially mentioned:

(1) Four shots from a 6-inch B. L. R. at the corners of each plate, in the following order, viz:

Left upper corner of each plate, 24 inches from left, and 24 inches from upper edge.

Right upper corner of each plate, 24 inches from right, and 24 inches from upper edge.

Left lower corner of each plate, 24 inches from left, and 24 inches from lower edge.

Right lower corner of each plate, 24 inches from right, and 24 inches from lower edge.

(2) One shot from an 8-inch B. L. R. at the centre of each plate.

Ballistic details.

[6-inch B. L. R.]

Gun: 6-inch B. L. R. of 40 calibres; Mark III. No. 120.

Charge: 42.4 pounds Du Pont's brown prismatic powder.

Projectile: 6-inch armor-piercing shell, manufactured by Jacob Holtzer & Co., Unieux, France, brought up to the standard weight of 100 pounds by filling with sand and small fragments of iron.

Striking velocity, determined by previous firings	f. s.	2,075
Striking energy	f. t.	2,989
Striking energy per ton of plate, about	f. t.	325
Elevation for upper corners		+1° 44′
Elevation of lower corners		—1° 24′
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.50

Carriage: Central pivot; Mark IV. No. 93.

[8-inch B. L. R.]

Gun: 8-inch B. L. R. of 35 calibres, Mark III. No. 18.

Charge: 74.5 pounds Du Pont's brown prismatic powder.

Projectile: 8-inch Firminy armor-piercing shell, manufactured by T. Firth & Sons, Sheffield, England, brought up to the standard weight of 210 pounds by filling with sand and small fragments of iron.

Striking velocity, determined by previous firings	f. s.	1,850
Striking energy	f. t.	4,989
Striking energy per ton of plate, about	f. t.	543
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.61

When the Carpenter projectile was used:

Charge: 72.5 pounds Du Pont's brown prismatic powder.

Projectile: 8-inch armor-piercing shell, manufactured by the Carpenter Steel Company, Reading, Pa., brought up to the standard weight of 250 pounds by filling with sand and small fragments of iron.

Striking velocity	f. s.	1,700
Striking energy	f. t.	5,008
Striking energy per ton of plate, about	f. t.	545
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.63

Carriage: Central pivot, Mark IV. No. 15.

The total striking energy of the five projectiles was 16,940 foot tons, equal to about 1,845 foot tons per ton of plate. In the case of the Carnegie, Phipps & Co. high-carbon nickel-steel Harvey plate, the total striking energy of the four projectiles was 13,975 foot tons, equal to 1,965 foot tons per ton of plate.

TRIAL No. 1.

Low-carbon steel, Harveyized, manufactured by Carnegie, Phipps & Co. (See Pl. x.)

The face of this plate was warped convex in final treatment, and in order to fit the surface of the backing its back was planed true. The centre of the plate was left at its normal thickness, while the corners were reduced to 8.8 inches. The thinning did not extend much inside the outer line of bolt holes, and the thickness at each point of impact is given below. The decrease of weight resulted in increasing the striking energy per ton of plate to 1,959 foot tons.

Firing details.

First shot.—Thickness of plate at point of impact, 10 inches. The projectile perforated the plate and remained apparently intact in the backing, its base 22 inches inside the face of the plate. The estimated penetration of the point was 39.34 inches. A bulge was formed on the face of the plate 16.5 inches in diameter with a broken fringe about the hole 2.25 inches high; about one-third of the fringe was clipped off, and there were a few radial hair cracks in the bulge. A through crack was developed about the right upper corner of the plate, extending from the top 9.5 inches to the left of this corner, and to the right side 29 inches below the same. The bulge on the back of the plate was 17 inches in diameter and 6.5 inches high, with a star of cracks about the hole through which the projectile had passed. A ragged hole corresponding in shape to the back bulge was made in the backing, and the projectile was lodged therein with its base 12 inches from the face thereof.

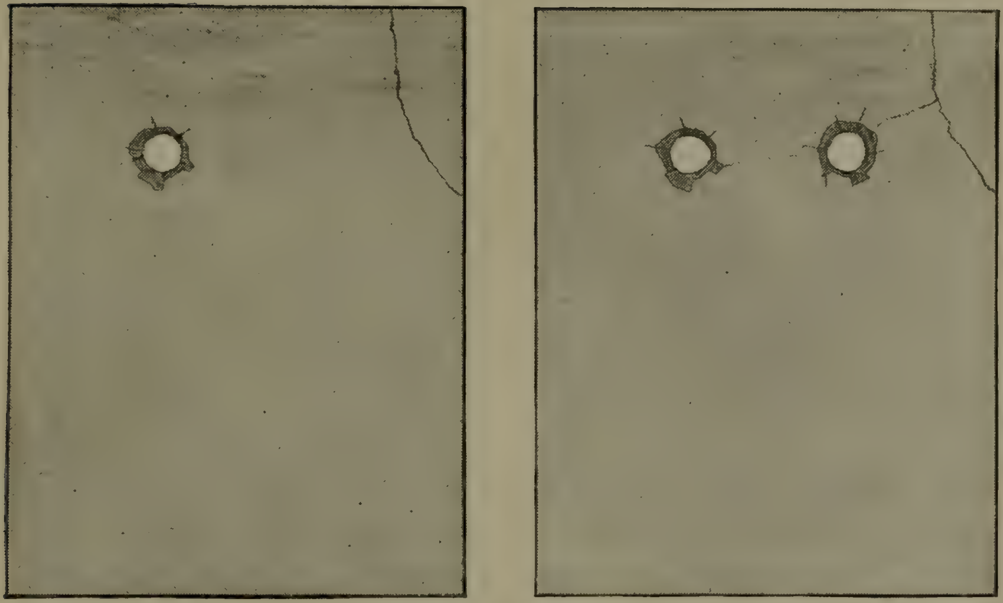
Second shot.—Thickness of plate at point of impact, 10.2 inches. The projectile perforated the plate and remained apparently intact in the backing, its base 12.5 inches inside the face of the plate. The estimated penetration of the point was 29.82 inches. A bulge was formed on the face of the plate 16.5 inches in diameter with a ragged fringe 2 inches high near the hole, with several radial hair cracks in the bulge. The crack about the right upper corner of the plate made by the first shot was widened, and the lower corner of the detached piece was sprung out 0.75 inch. A crack was formed from No. 1 to No. 2 hole, and from No. 2 toward the right upper corner joining the one above described. The bulge on the back of the plate was 17 inches in diameter and 4 inches high with a star of cracks about the hole through which the projectile had passed. About one-third of the metal of this bulge was broken off. The indent of the backing corresponded in shape to the back bulge. A fragment of the plate and the projectile remained in the backing, the base of the latter 2 inches inside the face thereof. The side wedges were loosened.

Third shot.—Thickness of plate at point of impact, 10.1 inches. The projectile perforated the plate and remained apparently intact in the backing, its base 17 inches inside the face of the plate. The estimated penetration of the point was 34.23 inches. A bulge was formed on the face of the plate 16.75 inches in diameter, with a ragged fringe about the hole 2 inches high. The cracks previously described were widened, and one developed from No. 1 hole to the left side of the plate, 29 inches from the top. The bulge on the back of the plate was 17 inches in diameter and 5.5 inches high, with a star of cracks about the hole through which the projectile had passed. The indent in the backing corresponded in shape to the back bulge, and was 12 inches in diameter and 8 inches deep, with one fragment of the plate sticking therein.

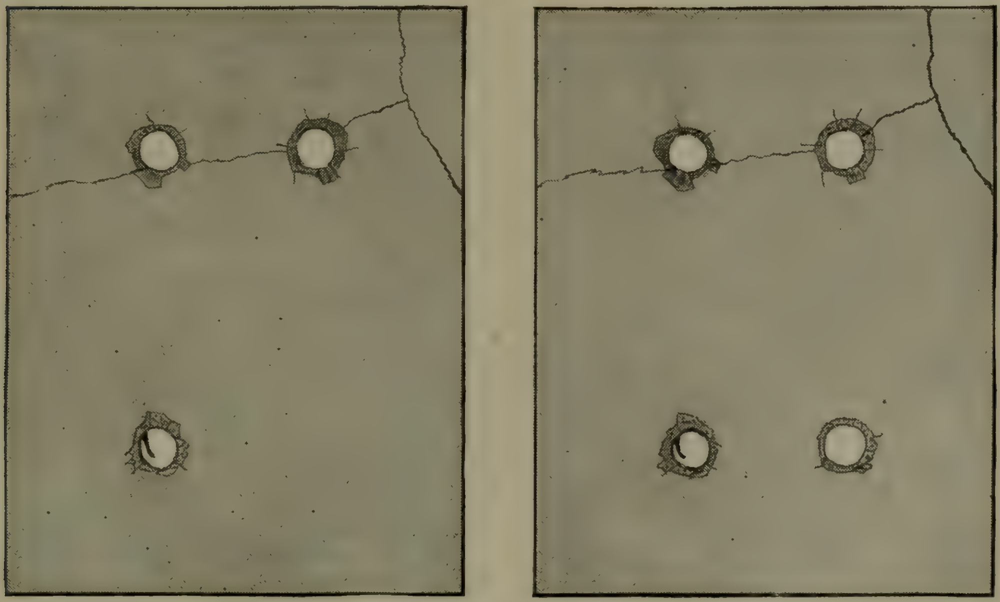
Fourth shot.—Thickness of plate at point of impact, 10.2 inches. The projectile perforated the plate and remained apparently intact in the backing, the base 25.5 inches inside the face of the plate. The estimated penetration of the point was 42.85 inches. A bulge was formed on the face of the plate 16 inches in diameter, with a ragged fringe 2 inches high about the hole. The bulge on the back of the plate was 17 inches in diameter and 4.5 inches high about the hole through which the projectile had passed. The indent in the backing corresponded in shape to the back bulge, and was 12 inches in diameter. The backing was broken entirely through and split between the points of impact of Nos. 3 and 4 shots.

Fifth shot (8-inch Carpenter a. p. shell).—Thickness of plate at point of impact, 10.4 inches. The projectile perforated the plate and backing, passed through one of the inclined struts, and striking a timber which supported the earth butt in rear of the target, was deflected over this butt, and fell about 100 yards to the rear of the target. The projectile was unbroken, and was shortened 0.26 inch, and expanded at bourrelet, 0.03 inch; at body, 0.04 inch; at base, 0.00 inch. A bulge was formed on the face of the plate 21.5 inches in diameter, with a ragged fringe 2 inches high about the hole. The plate was badly cracked, the cracks previously mentioned were

PLATE X.



HOLTZER *a. p.* PROJECTILES.



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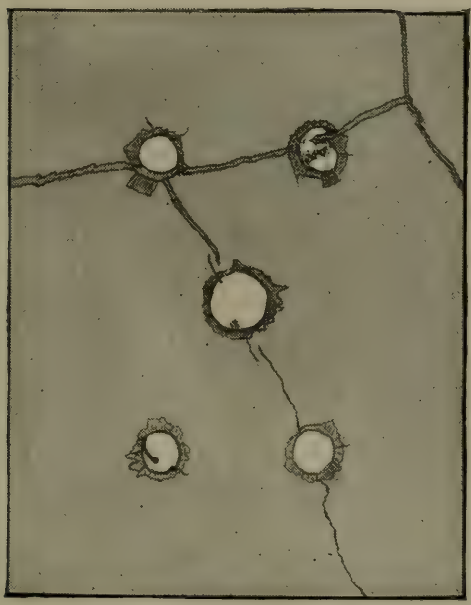
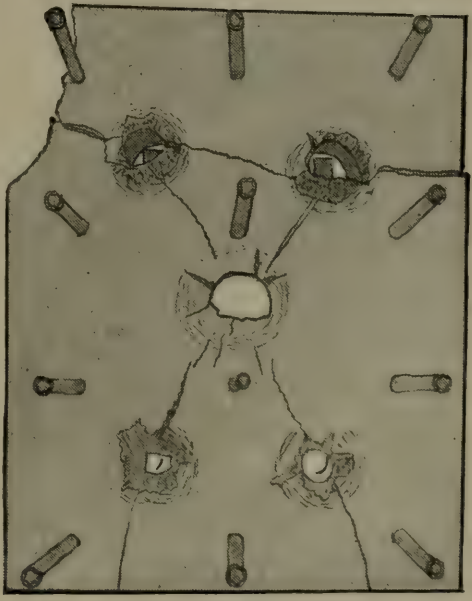


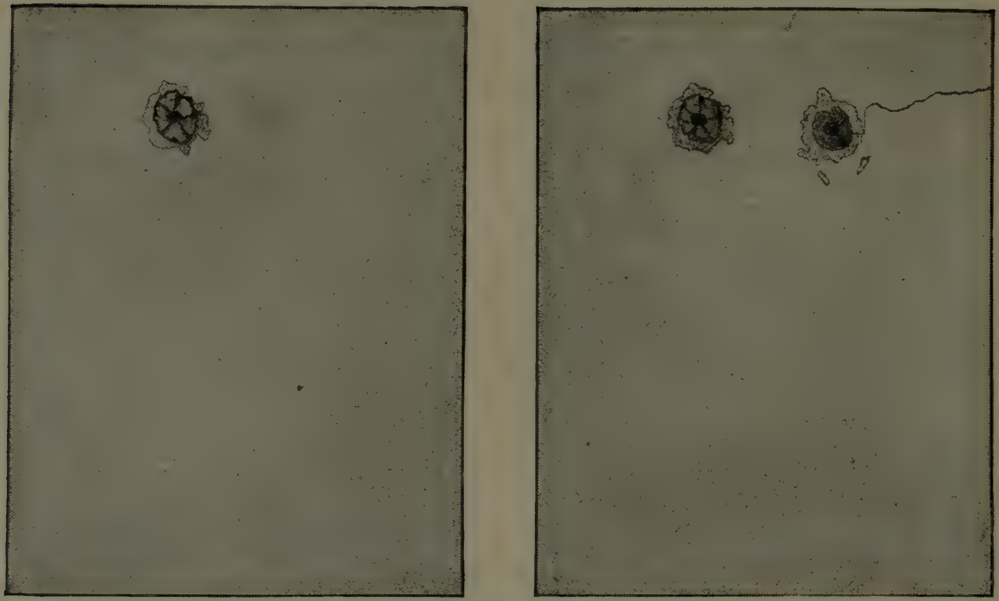
CARPENTER *a. p.* PROJECTILE.



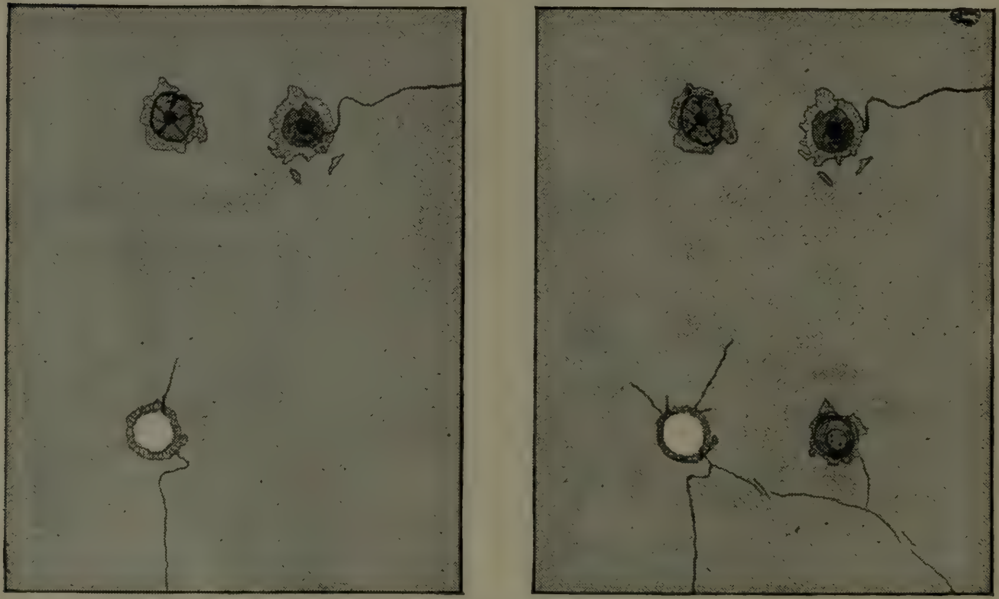
BACK OF PLATE.

CARNEGIE, PHIPPS & CO., LOW-CARBON STEEL. (HARVEY.)

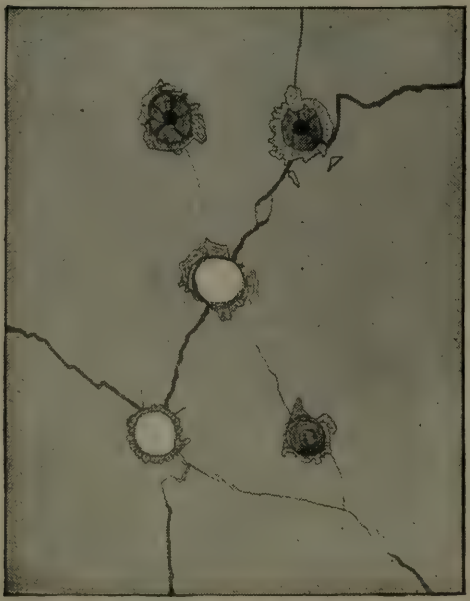
PLATE XI.



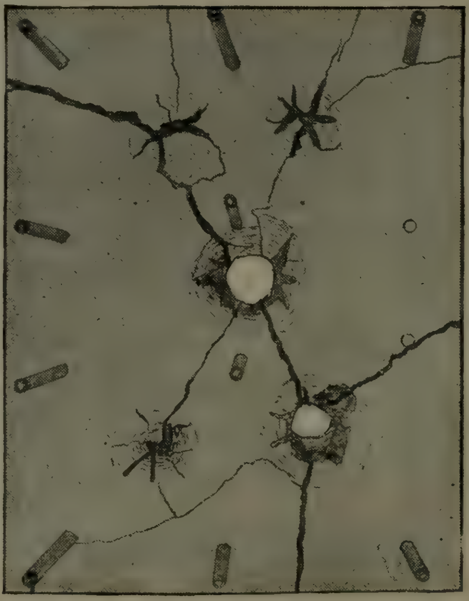
HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



FIRMINY *a. p.* PROJECTILE.



BACK OF PLATE.

BETHLEHEM LOW-CARBON STEEL. (HARVEY.)

widened to 1 inch, and a through crack extended from No. 1 through No. 5 and No. 4 holes to the bottom of the plate 16.5 inches from the right lower corner. The bulge on the back of the plate was 23 inches in diameter and 6 inches high, with a star of cracks about the hole through which the projectile had passed. There was a ragged hole 18 inches in diameter completely through the backing. When the plate was removed from the backing the small piece from the upper right corner fell off, and none of the armor bolts could be unscrewed.

The plate was clearly outmatched by the attack. The face was not hard enough to damage the projectiles on impact, the Holtzers remaining apparently intact, and the Carpenter only slightly damaged, and the whole energy of attack was expended on the plate; this, being soft, was perforated by every shot. The through-cracking was quite marked, but the plate, with the exception of the right upper corner, held together when removed from the backing. That it was strained beyond its limit of elasticity is shown by the gripping of the bolts, none of which could be unscrewed after the trial. It is not believed that the slight thinning of the plate at the points of Holtzer impacts made any material difference in the final results.

TRIAL No. 2.

Low-carbon steel, Harveyized, manufactured by Bethlehem Iron Company. (See Plate XI.)

Firing details.

First shot.—The projectile entered and broke up; the head split into twelve pieces with a very jagged fracture and remained in the plate, and the base was broken into small pieces, one of the larger of which being found about 100 yards to the front. The front end of the charge chamber was 2.75 inches inside the face of the plate.

The estimated penetration of the point was 10.07 inches.

A bulge was formed on the face of the plate 19 inches in diameter, with a maximum height about the hole of 0.75 inch. There was no curling fringe, but the metal about the hole chipped off.

The bulge on the back of the plate was 16 inches in diameter and 2 inches high, with a star of cracks opening from the point of the projectile.

The backing showed a slight depression, corresponding in shape to the bulge, 12 inches in diameter and 1.5 inch deep.

Two of the side-plate bolts were loosened.

Second shot.—The projectile entered and broke up; the head with a very jagged fracture remained in the plate. The body of the shell broke into many fragments. The front end of the charge chamber was 2.37 inches inside the face of the plate.

The estimated penetration of the point was 9.7 inches.

A bulge was formed on the face of the plate 18 inches in diameter with a maximum height about the hole of 1 inch. There was no curling fringe, but the metal about the hole was chipped off. A crack probed 5 inches deep, but was probably through and extended from the hole to the right side of the plate 18.37 inches from the top.

The bulge on the back of the plate was 18 inches in diameter and 1.62 inches high, with a star of cracks opening out from the point of the projectile.

The indent in the backing corresponded in shape with the back bulge, and was 12 inches in diameter and 1 inch deep.

Several of the side-plate bolts were started and loosened, and the upper left corner of the plate was sprung away from the backing 0.25 inch.

Third shot.—The projectile entered and remained apparently intact in the plate, the base 9.68 inches inside the face.

The estimated penetration of the point was 26.96 inches.

A bulge was formed on the face of the plate 16.25 inches in diameter, with a fringe about the hole 1.3 inches high, part of which was chipped off, and numerous radial hair cracks in the bulge not over 3 inches long.

The bulge on the back of the plate was 18 inches in diameter and 3.5 inches high about the hole through which the projectile had passed.

A crack extended from the hold to the bottom of the plate 24 inches from the left side, which probed 2.37 inches deep. The crack noted in No. 2 shot on this plate opened slightly and a surface crack developed upwards from No. 2 hole towards the top of the plate.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 2.5 inches deep. The projectile remained in the backing, its base projecting 1.5 inches from the surface.

The lugs of the wrought-iron clamp which held the bottom of the side plates were bent outwards and the right one cracked, showing that the side plates had been forced outward at the moment of firing.

Fourth shot.—The projectile entered and remained in the plate very much set up, the base projecting 6.37 inches from the face of the plate. The projectile near the bourrelet was expanded 1 inch, and there were two longitudinal cracks in the body; the base plug could be easily turned.

The estimated penetration of the point was 10 inches.

A bulge was formed on the face of the plate 16.25 inches in diameter and 1.5 inch high, much of the metal about the hole being chipped off.

A crack extended from No. 3 hole to the bottom of the plate 3.75 inches from the right side, which probed from 3 to 4.5 inches deep. A second crack extended from No. 4 hole vertically downwards and joined the last. Small surface cracks 15 inches long developed from hole No. 3.

The bulge on the back of the plate was 16 inches in diameter and 2 inches high, with a star of cracks opening out from the point of the projectile.

The indent of the backing corresponded in shape to the back bulge, and was 12 inches in diameter and 1 inch deep.

Fifth shot.—Projectile: Firminy armor-piercing shell of 210 pounds.

The projectile perforated the plate and remained, apparently intact, in the backing, the base 22.25 inches inside the face of the plate.

The estimated penetration of the point was 43.48 inches.

A bulge was formed on the face of the plate 22.5 inches in diameter and 1.25 inches high; the metal about the hole was chipped off.

A through crack reached from No. 2 to No. 3, passing through No. 5 hole, and all the previous cracks widened and some were much extended.

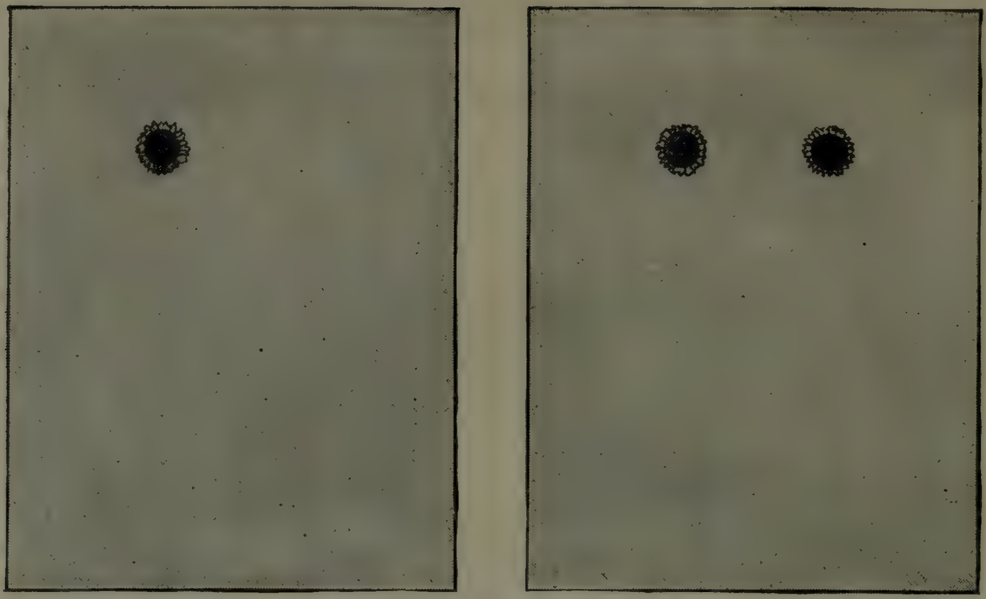
The bulge on the back of the plate was 24 inches in diameter and 8.37 inches about the hole through which the projectile had passed. The back of the plate showed, in addition, the following cracks which extended partly through the plate: One from No. 5 to No. 4 hole, and three from No. 1 hole, the first to the top of the plate, 13.5 inches from the left side; the second to the left side, 10 inches from the top; and the third to No. 5 hole.

The imprint in the backing corresponded in shape to the back bulge, and was 15 inches in diameter. The projectile remained in the backing.

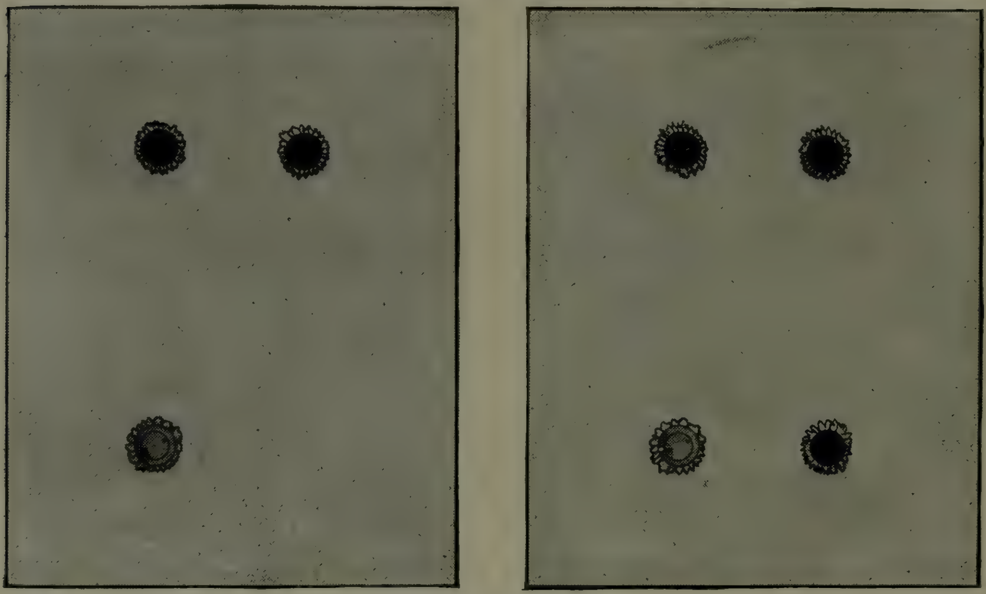
The backing was split and broken through in wake of the shot. The side plates were started away 1 inch at the top, and several of the backing bolts were driven back.

When the plate was removed from the backing it held together, and ten of the armor-plate bolts could not be unscrewed.

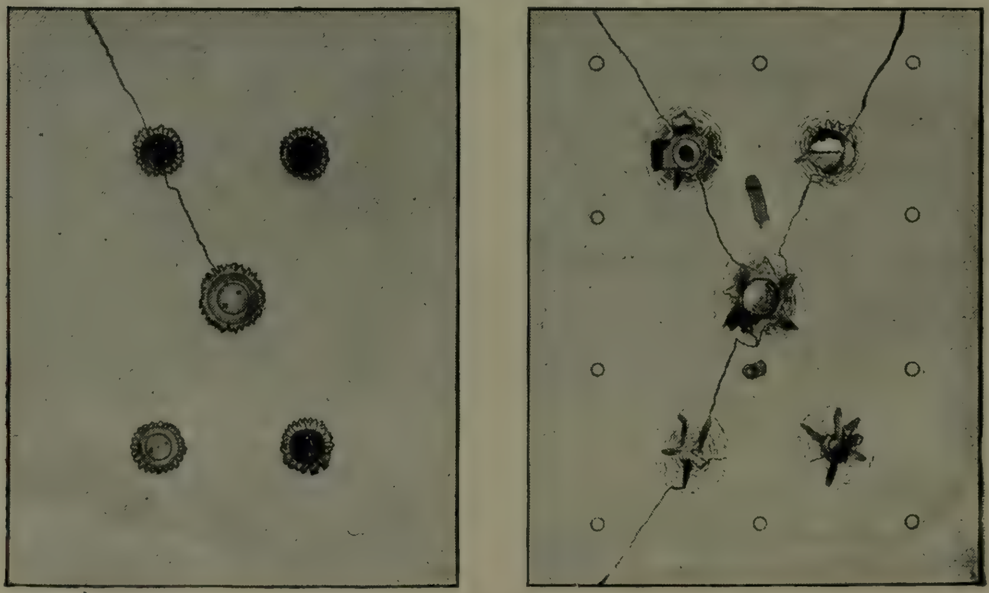
PLATE XII.



HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



FIRMINY *a. p.* PROJECTILE.

BACK OF PLATE.

CARNEGIE, PHIPPS & CO., LOW-CARBON NICKEL-STEEL.

This plate shows lack of uniformity in the hardness of the face. The effect on the first and second projectiles, considered in connection with the penetrations and diameters and heights of the back bulges, indicates that the greatest resistance was encountered by the projectiles on impact with the face, at which instant their rupture commenced, and consequently perforation energy was reduced. At the point of impact of the third shot there was evidently a lack of face hardness, and the projectile had no difficulty in getting through the soft plate, remaining intact. The fourth Holtzer was set up on inpact, increasing its diameter at the bourrelet an inch, which, with the energy thus expended, reduced the severity of its attack on the plate. The 8-inch projectile perforated with ease. Both of these plates exhibited the tendency of unalloyed steel to through-crack, and both were too soft to resist penetration without depending on the hardened face to break up the projectile on impact. The second plate showed better treatment in this respect, and being of a possibly higher grade of steel gave the better results.

TRIAL No. 3.

Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. (See Pl. XII.)

Firing details.

First shot.—The projectile entered and remained in the plate apparently intact, with its base 9.75 inches inside the face of the plate.

The estimated penetration of the point was 26.53 inches.

A bulge was formed on the face of the plate 18.5 inches in diameter, with a regular and curling fringe of metal about the hole 1.75 inches high.

No cracks.

When the plate was removed from the backing the projectile remained in the latter, with its base 1.5 inches from the normal surface thereof.

The bulge on the back of the plate was 16.5 inches in diameter, and 4.87 inches high about the hole through which the projectile passed.

The indent in the backing corresponded in shape to the bulge, and was 11 inches in diameter and 4 inches deep. Two small pieces of the plate adhered to the backing. One of the side plate bolts was loosened.

Second shot.—The projectile entered and remained in the plate, broken into two pieces, with its base 9 inches beyond the surface of the plate.

The estimated penetration of the point was 26.32 inches.

A bulge was formed on the face of the plate 18.75 inches in diameter, with a regular and curling fringe about the hole 1.75 inches high.

No cracks.

When the plate was removed from the backing the projectile was found broken at the rotation band, the head sticking in the backing and the base in the plate.

The bulge in the back of the plate was 17 inches in diameter and 4.5 inches high.

The indent in the backing corresponded in shape to the back bulge; was 11 inches in diameter and 4 inches deep. Two small fragments of the plate adhered to the backing.

The upper part of the plate was sprung away from the backing 0.5 inch.

Third shot.—The projectile entered and remained in the plate apparently intact. The base plug could be turned while the projectile was warm, but when cold was set fast. The base of the projectile projected 2.69 inches from the face of the plate.

The estimated penetration of the point was 14.6 inches.

A bulge was formed on the face of the plate 16.5 inches in diameter, with a regular and curling fringe about the hole 1.44 inches high.

No cracks.

The bulge on the back of the plate was 17 inches in diameter and 4.25 inches high about the hole, 2 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2.75 inches deep.

The top of the plate was sprung 0.75 inch away from the backing.

Fourth shot.—The projectile entered, broke into several pieces, and rebounded, the head and a portion of the body in one piece being found 29 feet 6 inches to the front and 25 feet to the right. The head parted from the body at the bourrelet for about 300 degrees with a single piece of the body about 4 inches long adhering thereto.

The penetration of the point was 13.19 inches.

A bulge was formed on the face of the plate 17.5 inches in diameter, with a regular and curling fringe about the hole 1.75 inch high.

No cracks.

The bulge on the back of the plate was 18 inches in diameter and 2.87 inches high about the hole, 2 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2.5 inches deep, with a small fragment of the plate sticking therein. The course of backing next to the plate was split between No. 3 and No. 4 hole.

Fifth shot.—Projectile: Firminy armor-piercing shell of 210 pounds.

The projectile entered and remained in the plate apparently intact, with its base 0.87 inch inside the face of the plate.

The estimated penetration of the point was 22.08 inches.

A bulge was formed on the face of the plate 21 inches in diameter, with a regular and curling fringe about the hole 1.87 inch high.

A through crack extended from this to No. 1 hole and thence to the top of the plate 10.5 inches from the left side.

The back of the plate showed in addition a through crack from No. 5 through No. 4 hole to the bottom of the plate, and a very fine crack, not through, from No. 5 through No. 2 hole to the upper edge of the plate 11 inches from the right corner.

The bulge on the back of the plate was 24 inches in diameter and 6.5 inches high about the projectile.

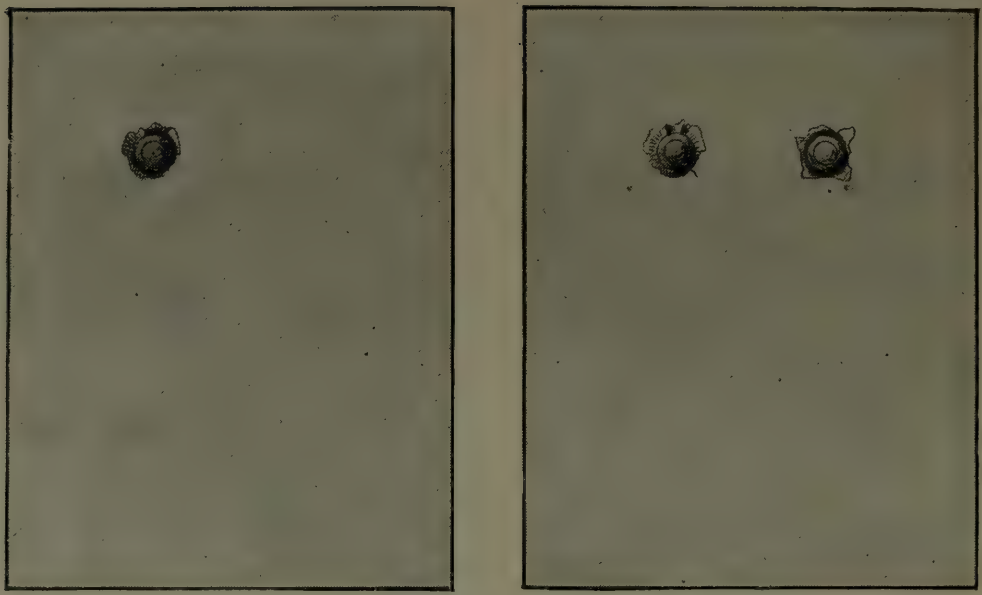
The indent in the backing corresponded in shape to the back bulge, was 14 inches in diameter, and the imprint of the point of the projectile was 10.75 inches deep.

Five of the backing and one of the armor bolts were started.

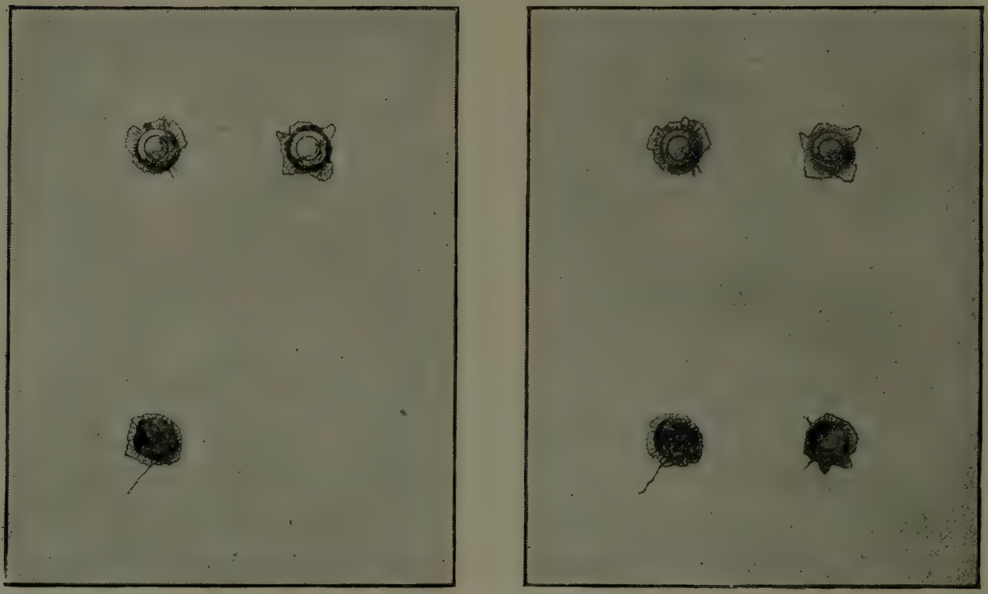
When the plate was removed from the backing it held together and all the armor bolts but two were easily unscrewed.

The penetrations of shots Nos. 1 and 2 being about twice those of Nos. 3 and 4, show lack of uniformity in the upper and lower halves of the plate, due, probably, to the manner in which it was tempered. The penetrations and back bulges show the plate to have been too soft; for, although complete perforation was not accomplished, it was only prevented by a very narrow margin in the first two shots. The tenacity imparted by the use of nickel alloy is shown by the absence of cracks after the fourth shot, they having been developed in both of the preceding trials at this stage of the firing, and also by the limited extent of cracking produced by the severe attack of the 8-inch Firminy a.p. projectile. Another illustration of the toughening effect of the nickel

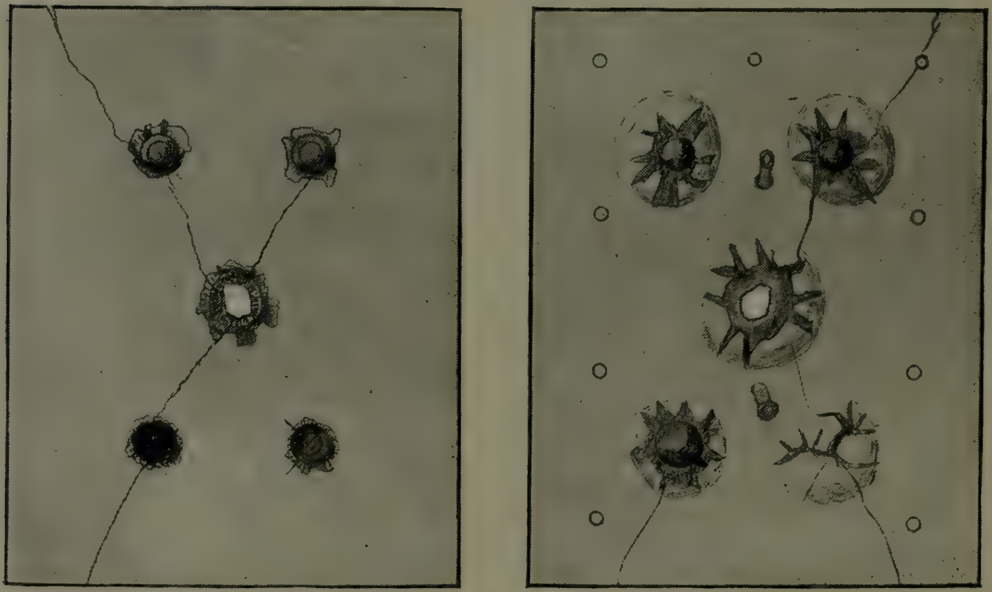
PLATE XIII.



HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



CARPENTER *a. p.* PROJECTILE. BACK OF PLATE.

CARNEGIE, PHIPPS & CO., LOW-CARBON NICKEL-STEEL. (HARVEY.)

is the manner in which the bolts admitted of easy removal, showing that the plate had not exceeded its limit of elasticity in resisting the attack, except that of the fifth shot, and that it was still capable of presenting a fair amount of resistance to through cracking. After the fourth round it might have been questionable whether, with the absence of cracks but increased penetrations, this plate should be classed as superior or inferior to that of trial No. 2; but the fifth shot settled the question without a doubt in favor of the nickel-steel plate.

TRIAL NO. 4.

Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate. (See Pl. XIII.)

Firing details.

First shot.—The projectile entered and remained apparently intact in the plate, the base projecting 2.62 inches from the face of the plate, the axis slightly inclined from the normal. A very small piece was found broken off from the extreme point of the projectile and two flakes were started from the head, halfway between the point and the bourrelet, adhering firmly at their rear ends.

The penetration of the projectile was 14.6 inches, the axis slightly inclined to the normal.

A bulge was formed on the face of the plate 18 inches in diameter, with a chipped fringe about the projectile 2.37 inches high, and a number of radial hair cracks in the bulge not over 4 inches long.

The bulge on the back of the plate was 21.5 inches in diameter and 4.12 inches high, with a star of cracks opening from the hole 5.5 inches wide, through which the point of the projectile had passed.

The indent in the backing was jagged, 4 inches deep at centre, and 14 inches in diameter. A small fragment of the plate adhered thereto.

One of the side-plate bolts was started.

Second shot.—The projectile entered and remained apparently intact in the plate, the base projecting 2.44 inches from the face of the plate, the axis slightly inclined to the normal.

The estimated penetration of the point was 14.86 inches.

A bulge was formed on the face of the plate 15.5 inches in diameter, with a ragged fringe about the hole 2 inches high and a number of radial hair cracks in the bulge not over 4 inches long.

A bulge on the back of the plate was 22 inches in diameter and 4.75 inches high about the hole, 5.12 inches wide, which opened out with a star of deep cracks from the point of the projectile.

The indent in the backing was jagged, corresponding in shape to the back bulge, 11 inches in diameter and 4 inches deep. The course of the backing next to the plate was split between shot holes No. 1 and No. 2.

One of the side-plate bolts was started.

Third shot.—The projectile entered the plate and rebounded to the front 12 feet 6 inches, and thence ricocheted 35 feet 2 inches beyond. It was considerably upset, being shortened 2.09 inches and expanded at the bourrelet 0.86 inch, at the body 0.58 inch, and at the base 0.01 inch. A number of small thin pieces flaked off the head.

The penetration of the point was 9.75 inches.

A bulge was formed on the face of the plate 16.75 inches, with an irregular, ragged, curling fringe 2.25 inches high about the hole and a number of radial hair cracks in the bulge not over 4 inches long.

The bulge on the back of the plate was 19.5 inches in diameter and 1.81 inch high about the hole, 1.25 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge, and was 11 inches in diameter and 1.37 inch deep.

Fourth shot.—The projectile entered and remained, apparently intact, in the plate, with the base 3.3 inches inside the face.

The penetration of the projectile was 20.5 inches.

A bulge was formed on the face of the plate 16.5 inches in diameter, with a broken curling fringe about the hole 2 inches high and a few radial hair cracks in the bulge about 3 inches in length.

The bulge on the back of the plate was 18 inches in diameter and 4.62 inches high about the projectile, with a star of cracks extending therefrom.

The indent in the backing was a jagged hole 12 inches in diameter corresponding to the back bulge, with the imprint of the point of the projectile 10 inches deep, and two small fragments of the plate sticking therein.

Fifth shot.—Projectile: 8-inch Carpenter armor-piercing shell of 250 pounds.

The projectile entered the plate, rebounded 33 feet to the front, broke into several pieces, the head being thrown 22 feet 10 inches to the front, and the body 33 feet to the right. The extreme point of the head was bruised and a piece chipped off.

The penetration of the point of the projectile was 17.25 inches.

A bulge was formed on the surface of the plate 18.5 inches in diameter, with an irregular broken fringe about the hole 2.5 inches high, and a few radial hair cracks in the bulge.

Through cracks extended from hole No. 5 through No. 1 to the top of the plate, 6.75 inches from the left upper corner, and through No. 3 to the bottom of the plate, 11 inches from the left lower corner; a deep crack extended from No. 5 to No. 2 hole.

In addition to the through cracks on the face of the plate a crack reaching nearly through the plate extended on the back from No. 5 through No. 4 hole to the bottom of the plate, 14.25 inches from the right lower corner.

The bulge on the back of the plate was 26 inches in diameter and 6.75 inches high at the hole, 5.5 inches wide, which opened out with a star of cracks from the point of the projectile.

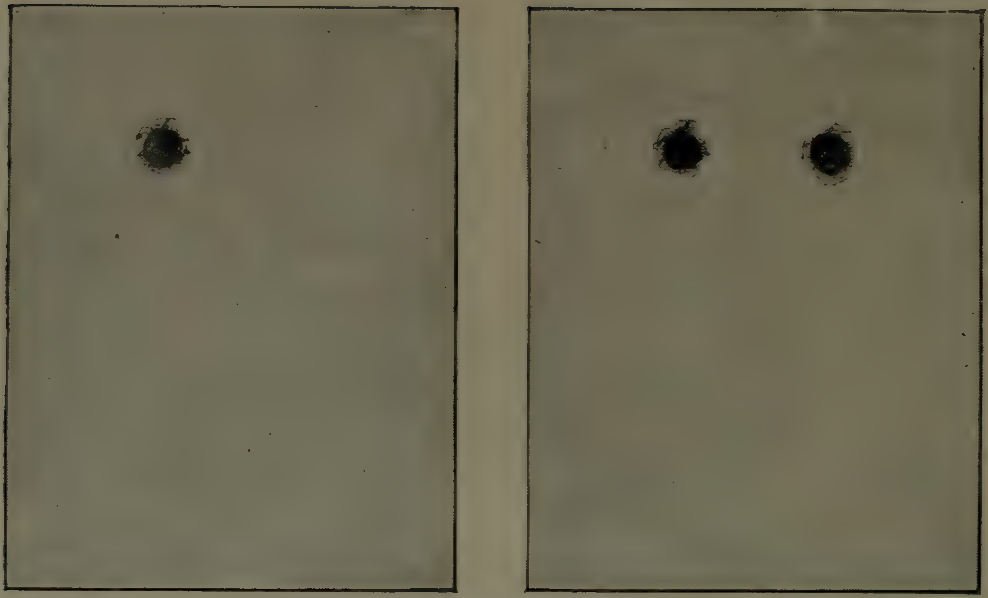
There was a jagged depression in the backing 16 inches in diameter and 5.5 inches deep, with a small fragment of the metal sticking therein. The course of the backing next to the plate was split in the line of the upper backing bolts.

When the plate was removed from the backing it held together, and the bolts were easily unscrewed, excepting the one above and the one below No. 5 hole.

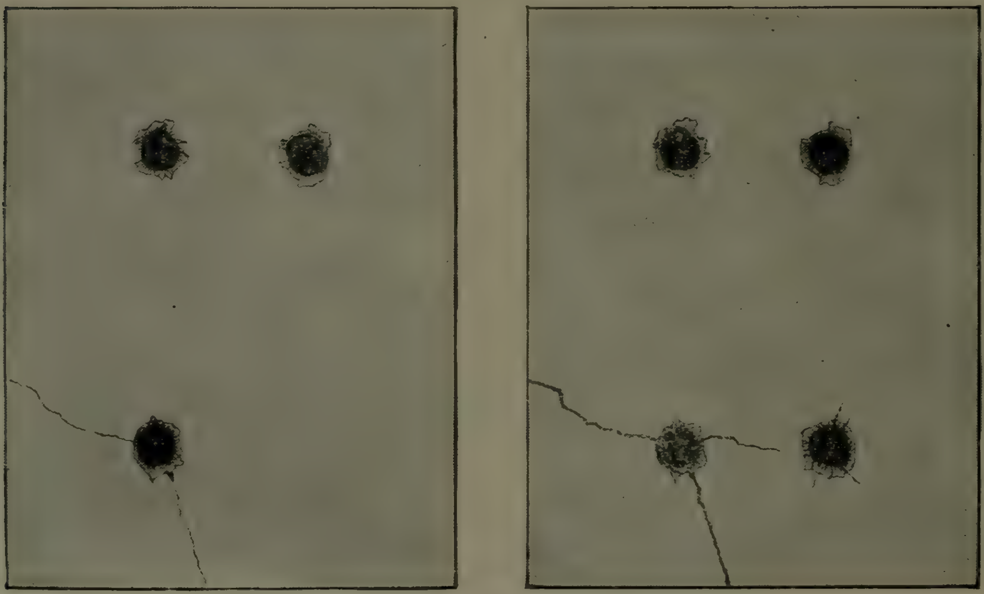
The top of the plate was, after the firing, sprung 0.25 inch away from the backing.

This plate showed better uniformity than the preceding one, but, while the Harvey face-hardening treatment undoubtedly added a little to its resistance to penetration, the upper half of the plate did not make as good a showing as the highly tempered lower half of that of the preceding trial, which was not Harveyized. Projectile No. 3 does not appear to have been up to the standard, it having set up badly, with consequent loss of work done on the plate; while shot No. 4, remaining intact, penetrated 20.5 inches. In comparing the results of the fifth shots on these last two plates, a doubtful element is introduced by the employment of different types of projectiles. The difference in penetrations is undoubtedly due to the loss of energy expended on the rupture of the Carpenter projectile; but whether this breaking up was due to inferiority of the projectile or to the harder face encountered is ques-

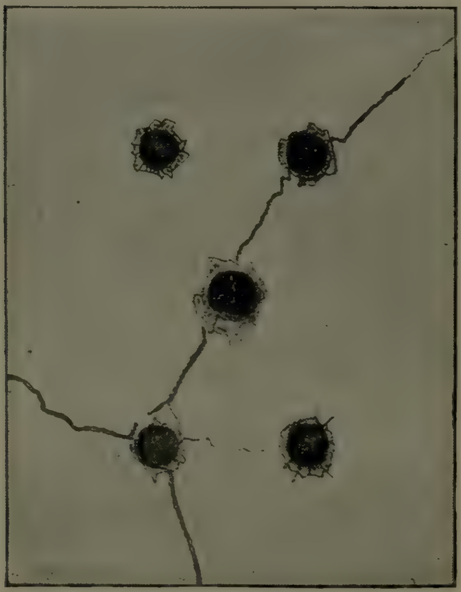
PLATE XIV.



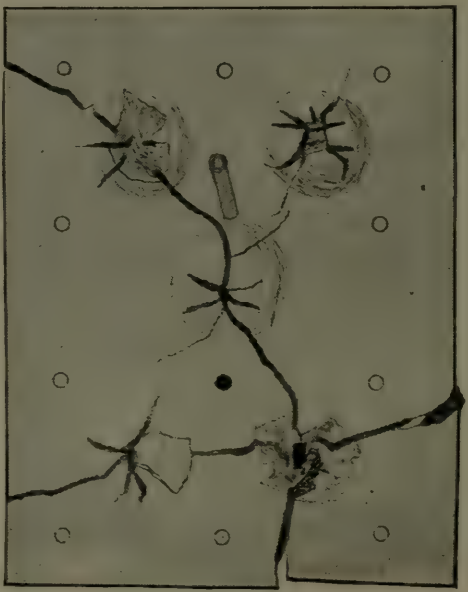
HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



CARPENTER *a. p.* PROJECTILE.



BACK OF PLATE.

CARNEGIE, PHIPPS & CO., HIGH-CARBON NICKEL-STEEL.

tionable. Taking into consideration the greater experience of the French makers, we are rather inclined to attribute the result to the inferiority of the Carpenter shell, aided, perhaps, by a slightly increased hardness of the plate. The through cracking of this plate was slightly greater, and is attributable to the shattering effect of the breaking projectile, although it may have been influenced by the decrease of 0.12 per cent nickel. The difference in the cracking, however, is so slight that the relative merits of the two plates can be judged by the effect of the 6-inch projectile attack, which shows in favor of the Harveyized plate by a less average penetration of 3.5 inches, even when the results of shot No. 3 are discarded. The action on the bolts was the same in both plates. The grade of steel used in both plates was of 0.26 per cent carbon, so that, presuming both were tempered in the same manner, the superiority of this plate would seem to be due to its greater uniformity and to the Harvey face-hardening treatment which it received.

TRIAL NO. 5.

Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. (See Plate XIV.)

Firing details.

First shot.—The projectile entered and rebounded 46 feet 6 inches to the front, burying itself in the sand. A circumferential hair crack was found near the bourrelet and the projectile was shortened 0.1 inch and expanded at bourrelet 0.0 inch, at body 0.04 inch, at base 0.0 inch.

The penetration of the point of the projectile was 12.5 inches.

A bulge was formed on the face of the plate 18.5 inches in diameter, with a chipped fringe 2 inches high about the shot hole, and a number of radial hair cracks in bulge not exceeding 3 inches long.

The bulge on the back of the plate was 14.5 inches in diameter and 3.56 inches high about the hole, 2.5 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 13 inches in diameter and 2.62 inches deep.

Two of the side plate bolts were started.

Second shot.—The projectile entered the plate, broke into many small pieces and rebounded. The head about 10 inches long was recovered, fracture jagged and parallel to the bourrelet.

The penetration of the point was 10.75 inches.

A bulge was formed on the face of the plate 19.75 inches in diameter with a curling fringe, partly chipped off about the hole 1.56 inch high, and a few radial hair cracks in the bulge not over 3 inches long.

The bulge on the back of the plate was 15 inches in diameter, and 1.94 inch high about the hole 1.25 inch, which opened out with a star of cracks from the point of the projectile. Three large pieces of the bulge were broken off.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1.62 inch deep. A fragment of the plate 9 by 4 by 2.5 inches adhered to the backing.

Third shot.—The projectile entered the plate and rebounded, broken into several large and a number of small pieces; some of the former recovered, among which was half of the head, which had been split longitudinally.

The penetration of the point was 12 inches.

A bulge was formed on the face of the plate 19.25 inches in diameter, with an irregular curling fringe partly chipped off about the hole 1.75 inch high, and a few short radial hair cracks in the bulge.

A through crack extended from this hole to the bottom of the plate 28.75 inches from the left lower corner, which was sprung out about 0.5 inch.

The bulge on the back of the plate was 16 inches in diameter and 2.37 inches high about the hole 2 inches wide, which opened out with a star of cracks from the point of the projectile; about half of the bulge was broken out to a depth of about 1.5 inch.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 2.5 inches deep. One small fragment of the plate was imbedded in the backing.

Fourth shot.—The projectile entered the plate and rebounded 47 feet 10 inches to the front; in it were two longitudinal cracks, one from the bourrelet to the base, apparently a through crack, and the other extending from the bourrelet to the band score.

The projectile was shortened 0.11 inch and expanded at the bourrelet 0.03 inch, at the body 0.08 inch, and at the base 0.02 inch.

The penetration of the point was 11.87 inches.

A bulge was formed on the face of the plate 18 inches in diameter with a curling fringe about the hole, partly chipped off, 1.87 inch high, and several radial hair cracks in the bulge not over 3 inches long.

One through crack extended from this through No. 3 hole to the side of the plate, 35.5 inches from the left lower corner, and the one mentioned in round 7 was slightly opened.

The bulge on the back of the plate was 20 inches in diameter and 2.87 inches high around the hole, 2.75 inches wide, opening out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2 inches deep, with a small fragment of the plate sticking therein.

Both of the lugs of the bottom clamp holding the side plates were cracked.

Fifth shot.—Projectile: 8-inch Carpenter armor piercing shell of 250 pounds.

The projectile entered and rebounded 6 feet 3 inches to the front, very much set up and cracked. The cracks were generally longitudinal, and many thin pieces flaked off from the head. The projectile was very hot and was still warm an hour after. It was shortened 3.58 inches, and expanded at bourrelet 1.65 inch, at the body 0.97 inch, at the base 0.28 inches.

The penetration of the point was 9.62 inches.

A bulge was formed on the face of the plate 20 inches in diameter, with an irregular fringe about the hole 1.75 inch high and a few radial hair cracks in the bulge.

A through crack extended from the No. 3 through No. 5 and No. 2 holes to the right side of the plate, 7 inches from the top, and those developed at No. 3 and No. 4 shots were somewhat opened.

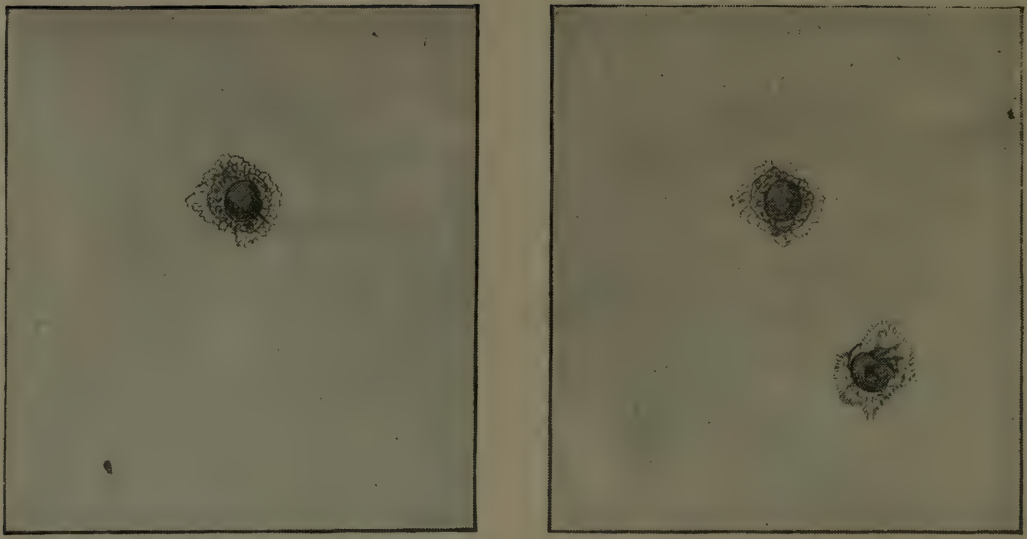
In addition to the through cracks on the face of the plate, the following, extending nearly through the plate, were found on the back: One from No. 5 through No. 1 hole to the top of the plate, 15.5 inches from the left upper corner, and one from No. 4 hole to the right side of the plate, 18 inches from the right lower corner.

The bulge on the back of the plate was 25 inches in diameter and 1.56 inch high, about the hole 1.25 inch wide, which opened out with a star of cracks from the point of the projectile.

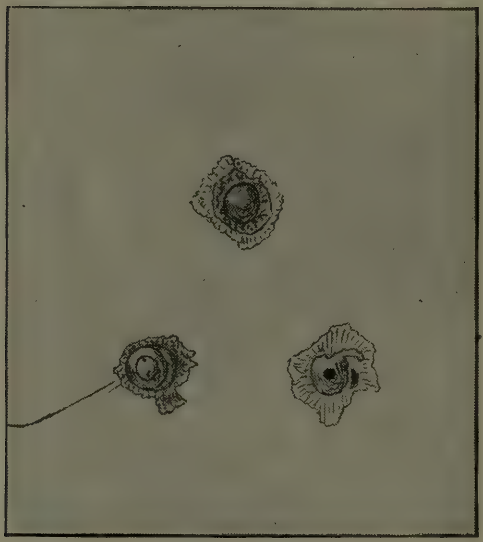
The indent in the backing corresponded to the back bulge, and was 13 inches in diameter and 1 inch deep.

The middle armor bolt of the second row from the bottom was broken at the plate and thrown 2 feet to the rear; both of the lugs of the bottom clamp for the side

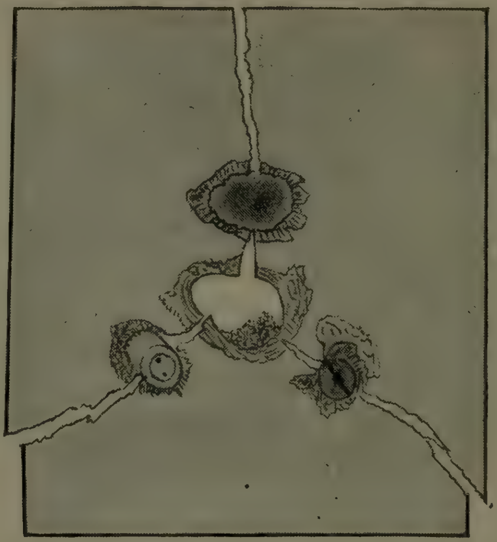
PLATE XV.



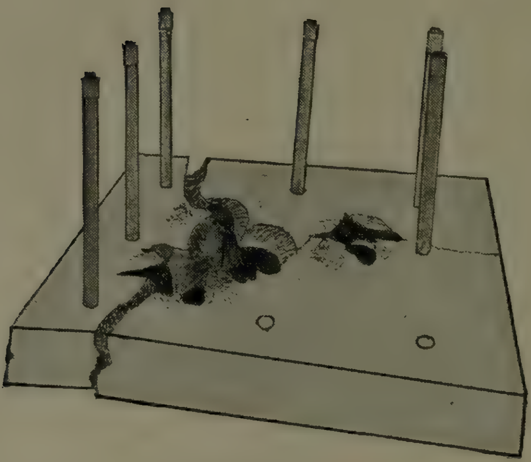
HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILE.



CARPENTER *a. p.* PROJECTILE.



BACK OF PLATE.

CARNEGIE, PHIPPS & CO., HIGH-CARBON NICKEL-STEEL. (HARVEY.)

plates were broken. The backing structure was set back 0.5 of an inch, and the course of backing next to the plate was split.

When the plate was removed from the backing the left lower corner separated from the remainder of the plate. The armor bolt above No. 5 hole stuck in the plate; the one below it was broken off flush with the back of the plate; the remaining bolts were easily unscrewed.

The top of the plate was, after the firing, sprung 0.25 of an inch away from the backing.

This plate contained 0.19 per cent more carbon and 0.09 per cent less nickel than the one in the preceding trial. The effect of the hard steel was disastrous to the projectiles, all of which were either cracked or shattered; but as the hardness was distributed throughout the mass of the plate, and not concentrated on the face, considerable penetration was accomplished before the rupture of the projectiles, which resulted at the third shot in one through crack and the possible starting of another, which did not develop on the face until the fourth round, when a third crack was also made. The Board attributed the small penetration of the fifth shot to the excessive setting up of the projectile, which, however, succeeded in producing a large through crack. Although the extent of through cracking was greater in this plate than in that of the preceding trial, it was not sufficient to dislodge any of the parts of the plate from the backing with the system of bolting employed; and this fact taken in consideration, combined with its marked superiority in resistance to penetration, as shown by an average of 3.15 inches less for the four Holtzers, with a resulting average decrease of 4.2 inches diameter and 1.15 inches height of back bulges, shows this plate to have been capable of affording protection to a better degree than that of trial No. 4. That life still remained in the undamaged portions of the plate, is evidenced by the removal of all but two of the bolts by unscrewing them.

TRIAL No. 6.

High-carbon, nickel-steel, Harvey, manufactured by Carnegie, Phipps & Co. (See Plate XV.)

Firing details.

First shot.—Point of impact was 24 inches from the top and 36 inches from the left side of the plate. The projectile entered the plate and rebounded 56 feet to the front and then back toward the plate 16 feet. A piece was found to have flaked off near the bourrelet about 6 inches square, and an hour later, while standing on its base, the greater part of the head of the projectile flaked off. The penetration of the point was 11.5 inches. A bulge was formed on the face of the plate 18.5 inches in diameter, with a ragged fringe about the hole 2 inches high, the greater part of which was chipped off. No cracks. The bulge on the back of the plate was 18 inches in diameter, which, with a star of cracks, opened out from the point of the projectile. The greater part of the metal of the back bulge was torn off, forming a partial crater 2 inches at its greatest depth. The indent in the backing corresponded in shape to the back bulge and was 6 inches in diameter and 4 inches deep.

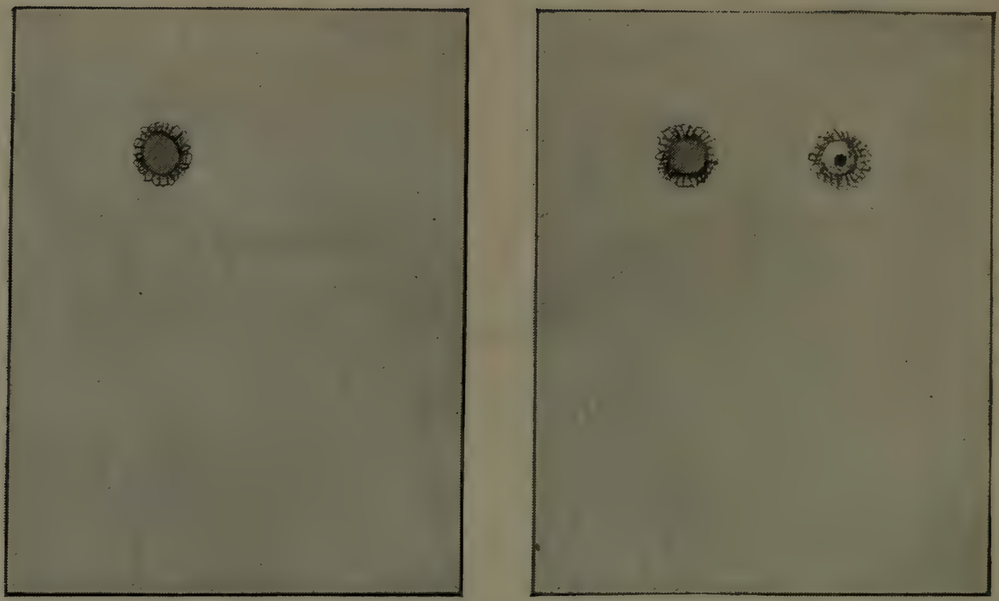
Second shot.—Point of impact was 24 inches from the bottom and 24 inches from the right side of the plate. The projectile entered the plate and broke up, the head, badly cracked, remaining in the plate with the front end of the chamber 6 inches inside the face of the plate. The estimated penetration of the point was 13.32 inches. A bulge was formed on the face of the plate 16 inches in diameter, with a ragged fringe 1.75 inches about the hole. No cracks. The metal on the back was torn away by the point of the projectile, thus forming a ragged crater 18 inches in diameter and 1.5 inches deep about the hole, 4 inches in diameter, opposite the point of the projectile. The indent in the backing corresponded in shape to the back bulge and was 13 inches in diameter and 3 inches deep. Four fragments of the plate stuck in the backing.

Third shot.—The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate. The projectile entered and remained in the plate, its base protruding 6.12 inches. The succeeding shot released this projectile and it was found intact, except a small piece flaked off the head. The estimated penetration of the point was 11.22 inches. A bulge was formed on the face of the plate 17.5 inches in diameter, with a broken fringe about the shot 1.75 inches high and a few radial hair cracks in the bulge. A crack extended from No. 3 hole to the left side of the plate 16 inches from bottom. The bulge on the back of the plate was 17 inches in diameter and 3 inches high on one side; the other side was torn out 2 inches deep. A partial crater had been formed as by the previous shots at this plate. The indent in the backing corresponded in shape to the back bulge, and was 12 inches in diameter and 2 inches deep, one fragment of the plate adhering to the backing.

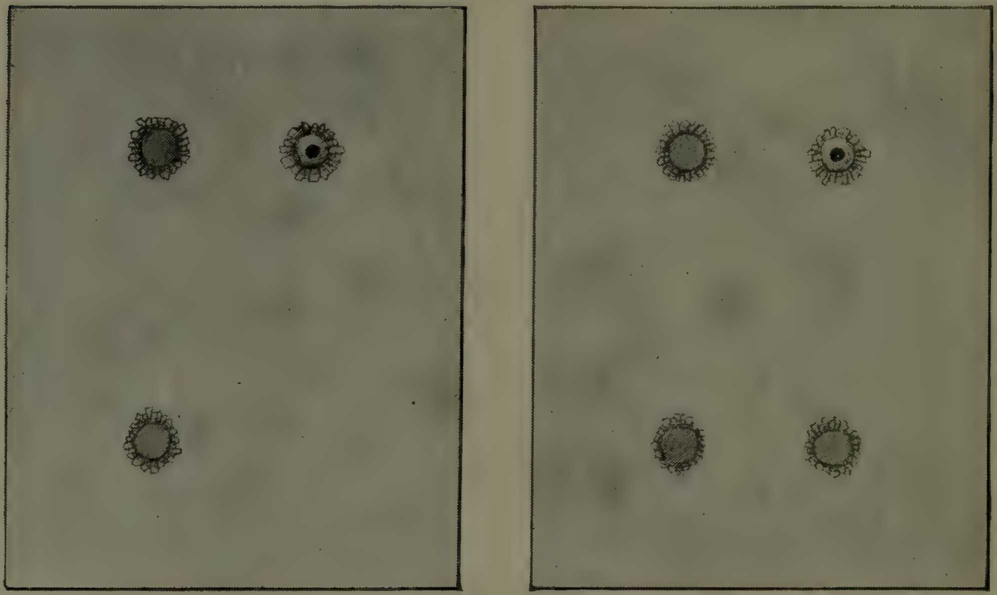
Fourth shot (8-inch Carpenter a. p. shell).—Point of impact was in the middle of the triangle formed by the preceding three shot holes. The shot perforated the plate and backing and buried itself in the butt. It was found broken into several pieces. A crater was formed on the face of the plate about 18 inches in diameter and 4 inches deep about the hole. Very wide cracks were formed, as follows: From No. 4 hole through No. 1 hole, 2.5 inches wide, to top of plate 34.75 inches from right upper corner; through No. 2 hole, 1.5 inches wide, to side of plate 7 inches from right lower corner; through No. 3 hole, 2.5 inches wide, to side of plate 16 inches from left lower corner. A crater was formed on the back of the plate 19 inches in diameter and 2 inches deep about the hole through which the projectile had passed. Through the backing was a ragged hole 15 inches in diameter, with three fragments of the plate buried therein. Both of the lugs of the bottom clamp were broken, and the left side of the plate was wrenched away from the backing and armor plate, as shown in Plate XV. When the plate was taken off the backing it separated into three pieces. Two of the armor bolts were broken off near the plate and the rest could not be unscrewed.

Owing to the different conditions of attack occasioned by the smaller size of this plate, the decision as to its relative merits, compared with those of the preceding trial, must involve, more or less, a question of opinion. The plates were very evenly matched, but whatever slight difference existed in their resistance qualities appears to have been in favor of this one, as determined principally by the appearance of the two plates before the attack of the 8-inch projectiles. The points of impact of the last two Holtzers being similar in both trials, with regard to bottom and side edges, they admit of ready comparison; while for a companion shot for the first shot of this trial we prefer shot No. 1 of the preceding trial to shot No. 2, as the punishment inflicted on its projectile was more nearly the same. The concentration of the points of impact was more severe on the smaller plate before the last round. Considering these three shots at each plate, we find the effect upon the projectiles about equal; the average penetrations practically the same,

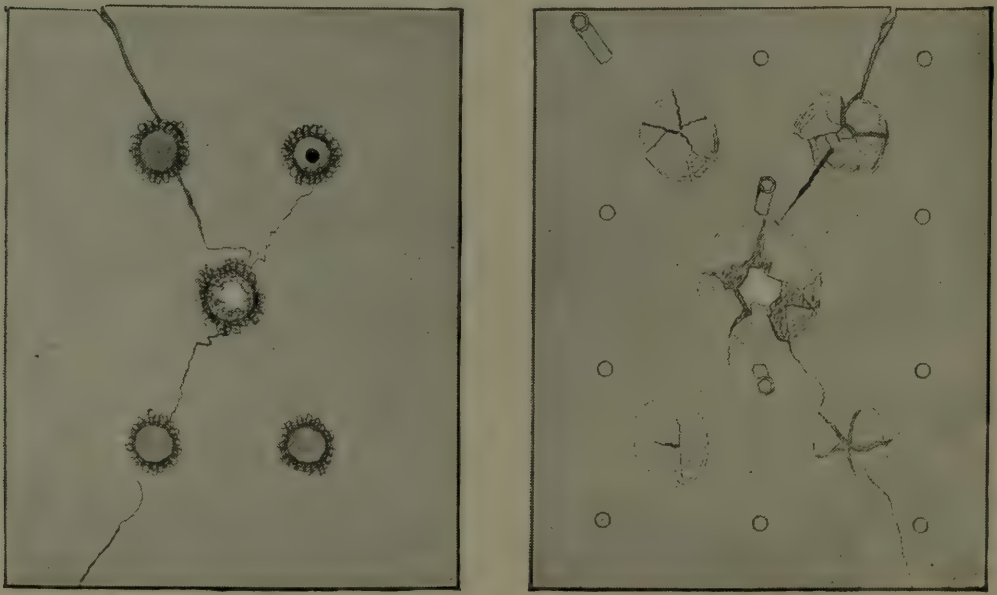
PLATE XVI.



HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



FIRMINY *a. p.* PROJECTILE.

BACK OF PLATE.

BETHLEHEM HIGH-CARBON NICKEL-STEEL.

being 0.11 inch in favor of the smaller plate, which slight advantage, combined with that of withstanding the concentrated attack, is offset by the increased backing indent of 0.63 inch; hence the relative merits of the two plates can be judged by the extent of through-cracking, ing, which was as three to one in favor of the smaller plate. The attacks of the 8-inch projectiles do not admit of comparison, the concentration of a striking energy of 13,975 foot tons within the space of 2½ square feet inclosed by the points of impact being decidedly more than the plate could be expected to resist. The excessive width of the cracks shown in Plate XV is due to the left side-brace of the backing giving way; but even had it held, the cracking would probably have developed, as it did, in the direction of the already weakened points.

Although this plate, treated by the Harvey process, is considered slightly superior to that of the preceding trial, not treated, it is difficult to see wherein its superiority is attributable to that treatment.

TRIAL NO. 7.

Bethlehem Iron Company's high-carbon nickel-steel plate. (See Plate XVI.)

Firing details.

First shot.—The projectile entered the plate and rebounded to the front 31 feet 10 inches, and ricocheted 19 feet 2 inches beyond. The projectile was unbroken, and was shortened 0.06; expanded at bourrelet 0.01, at body 0.03, at base 0.00.

The penetration of the point was 13.25 inches.

A bulge was formed on the face of the plate 16.5 inches in diameter, with a regular and curling fringe of metal about the hole 1.75 inch high, and radial hair cracks in the bulge 4.5 inches and 2.5 inches long.

The bulge on the back of the plate was 16.5 inches in diameter about the hole, 1.75 inches wide opposite the point of the projectile, from which a star of cracks opened out. A piece of metal, about one-third the bulge, was scaled off the back of the plate.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 1.75 inches deep.

The head of one of the side plate bolts was broken.

Second shot.—The projectile entered and broke into several pieces, the head with a jagged fracture and split into three equal pieces remaining in the plate. The front end of the chamber was 2.75 inches inside the face of the plate.

The estimated penetration of the point was 10.07 inches.

A bulge was formed on the face of the plate 18.5 inches in diameter with a regular and curling fringe about the hole 1.75 inches high. Three short surface radial cracks were developed in the bulge, 2 inches, 2.5 inches, and 2.75 inches long.

The bulge on the back of the plate was 17 inches in diameter and 2.12 inches high; about the hole 1 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 1.37 inches deep.

One of the side plate bolts was loosened. The top of the plate was separated from the backing 0.5 inch.

Third shot.—The projectile entered and rebounded unbroken to the front 15 feet, ricocheted 10 feet 6 inches farther, striking an oak timber, and rebounded 7 feet. It was shortened 0.06 inch, expanded at bourrelet 0.02 inch, at body 0.035 inch, at base 0.0 inch.

The penetration of the point was 12.75 inches.

A bulge was formed on the face of the plate 16.75 inches in diameter, with a regular and curling fringe 1.75 inches high around the hole, with three radial hair cracks in the bulge, each 3 inches long.

The bulge on the back of the plate was 15 inches in diameter and 2.75 inches high, about the hole 0.5 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2 inches deep.

Several bolts of the side plates were started and loosened.

The top of the plate was sprung away from the backing 0.75 inch.

Fourth shot.—The projectile entered, broke into several pieces and rebounded, the head being found 21 feet to the front.

The penetration of the point was 10.37 inches.

A bulge was formed on the face of the plate 17.25 inches in diameter, with a regular and curling fringe about the hole 1.87 inches high, and two radial hair cracks in the bulge 3 and 4 inches long.

The bulge on the back of the plate was 15 inches in diameter and 1.62 inches high, with a slight crack from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 10 inches in diameter and 1 inch deep.

The side plate bolts were started and the upper part of the plate was 0.75 inch away from the backing.

Fifth shot.—Firminy armor-piercing shell of 210 pounds. The projectile entered the plate and rebounded apparently intact 25 feet to the front, struck an oak timber, thence ricocheted 29 feet farther, striking bank, and rebounded 8 feet. It was shortened 0.12 inch, expanded at bourrelet 0.00 inch, at body 0.06 inch, at base 0.01 inch.

The penetration of the point of the projectile was 16.5 inches.

A bulge was formed on the face of the plate 20.75 inches in diameter, with a regular and curling fringe around hole 2.12 inches high. A wide crack radiated from this by No. 1 hole to the top of the plate 12.25 inches from the left side, another through No. 3 hole to the bottom of the plate 10.12 inches from its left side, and another to No. 2 hole, all of which extended through the plate.

The bulge on the back of the plate was 22 inches in diameter and 5.5 inches high about the ragged hole, 4.5 inches wide, made by the point of the projectile.

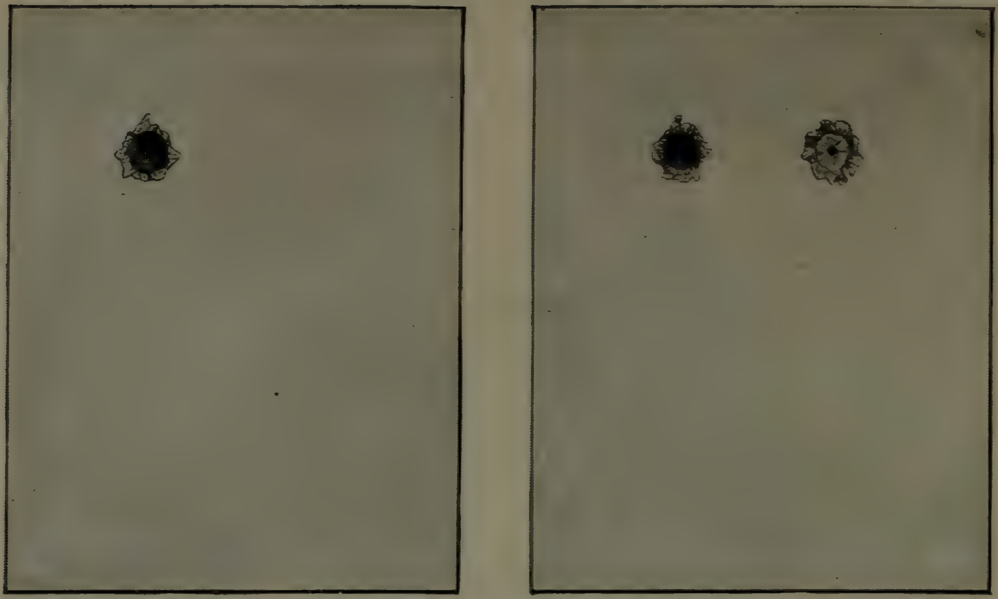
The indent in the backing corresponded in shape to the back bulge and was 15 inches in diameter and 4 inches deep, with the imprint of the point of the projectile sharply defined, 5.62 inches deep.

The entire target structure was set back about an inch, the bolts of the side plates loosened, and one of the backing bolts set back 4.5 inches. The top of the plate was sprung away from the backing 0.87 inch.

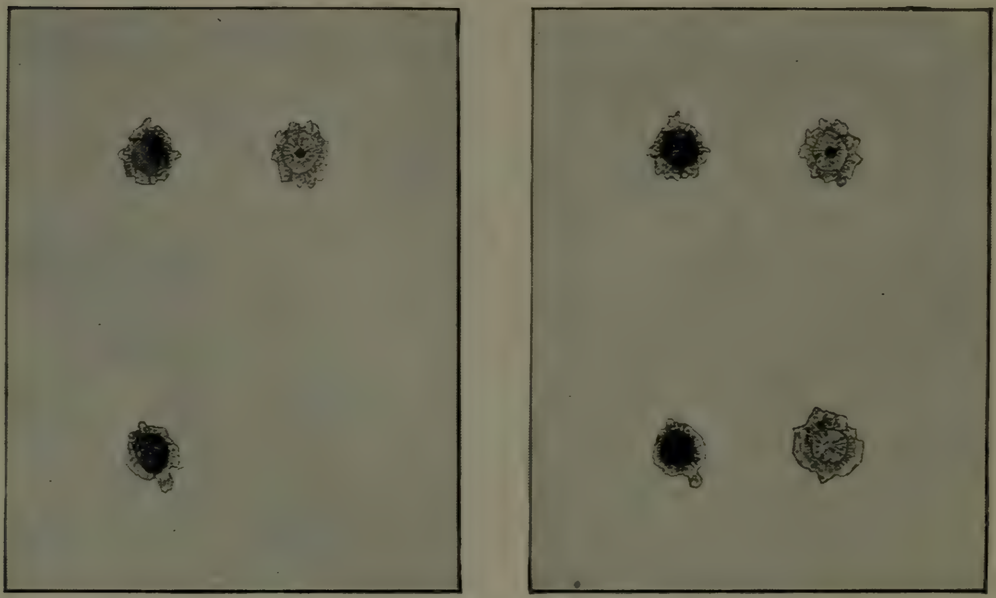
When the plate was removed from the backing it held together and all the armor bolts but three were easily unscrewed.

On account of the conditions of the trials, it is better to compare this plate with that of trial No. 5, remembering that trial No. 6 gave slightly better results than No. 5. The effect on the Holtzers was about the same in each trial, but the Bethlehem plate showed 0.17 inch less average penetration and 0.13 inch less average height of back bulges, with no cracks at the end of the fourth shot. The deformation of the 8-inch Firminy projectile was almost *nil*, so that its total striking energy was absorbed by the plate; whereas in trial No. 5, the Carpenter projectile was badly

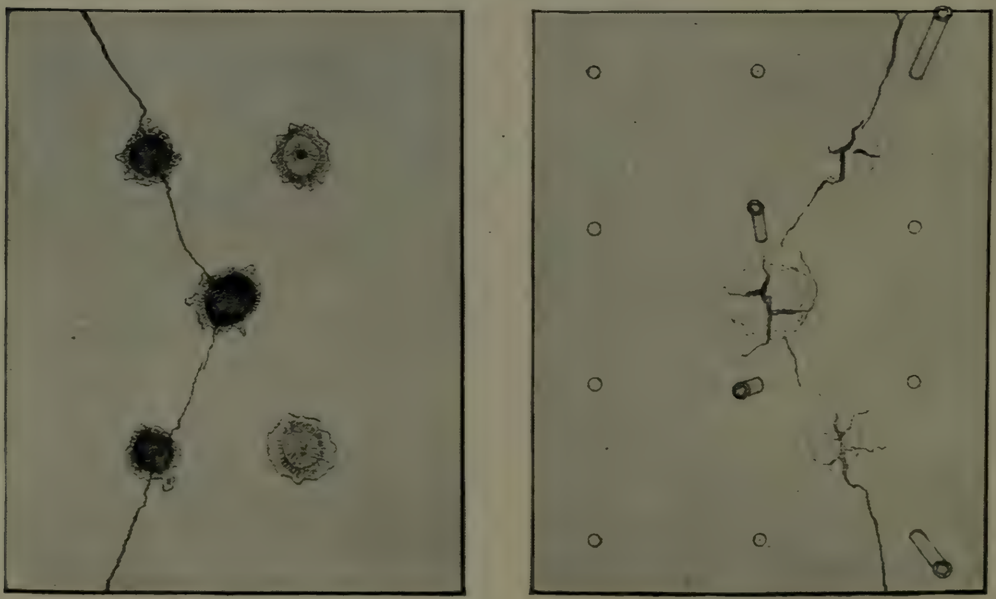
PLATE XVII.



HOLTZER *a. p.* PROJECTILES.



HOLTZER *a. p.* PROJECTILES.



FIRMINY *a. p.* PROJECTILE.

BACK OF PLATE.

BETHLEHEM HIGH-CARBON NICKEL-STEEL. (HARVEY.)

deformed, thus decreasing the work done on the plate. Perforation, however, was resisted, and, considering the severity of attack, the decreased extent of through cracking, and the better showing after the fourth round, there is no difficulty in placing this plate ahead of those of the two preceding trials in order of merit.

TRIAL NO. 8.

Bethlehem Iron Company's high-carbon nickel-steel Harvey plate. (See Plate XVII.)

Firing details.

First shot.—The projectile entered the plate, broke into three pieces, and rebounded, the largest piece being found 45 feet to the front and 10 feet 6 inches to the right. One piece was the point 3 inches long, another, longitudinal, extending from the base 7 inches and 5 inches wide; the remaining piece was somewhat cracked. The projectile was expanded at bourrelet 0.03 inch.

The penetration of the point was 12 inches.

A bulge was formed on the face of the plate 18.25 inches in diameter with a chipped fringe about the hole 1.12 inches high, and a number of radial hair cracks in the bulge not over 5 inches long.

The bulge on the back of the plate was 21 inches in diameter and 2.25 inches high about the hole 0.25 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1.5 inches deep.

The head of one of the side plate bolts was broken and two others loosened.

Second shot.—The point of the projectile entered and remained in the plate, presenting an appearance of being welded therein, the end of the chamber 0.5 inch outside of the plate; the body and base were broken into many small fragments, none of which were recovered.

The estimated penetration of the point was 6.82 inches.

A bulge was formed on the face of the plate 12.75 inches in diameter. Near the head of the projectile the metal of the plate was dished in and scarcely distinguishable from that of the projectile remaining in the plate. A few short radial hair cracks were in the bulge.

The bulge on the back of the plate was nearly imperceptible, but was found to be 18 inches in diameter and 0.25 inch high.

No cracks.

There was a discoloration of the backing opposite the back bulge, but no indent.

A head of one of the side plate bolts was broken.

Third shot.—The projectile entered the plate and rebounded 37 feet 10 inches to the front and thence ricochetted 19 feet farther. The projectile was unbroken, but there was a longitudinal crack from bourrelet to band score. It was shortened 0.14 inch and expanded at bourrelet 0.015 inch, at body 0.05 inch, at base 0.01 inch.

The penetration of the point was 12.25 inches.

A bulge was formed on the face of the plate 18 inches in diameter, with an irregular chipped fringe about the hole 1.5 inch high, and a number of radial hair cracks in the bulge not over 5 inches long. There were also three deeper radial cracks—two 6 inches, and one 5.5 inches long.

The bulge on the back of the plate was 15.25 inches in diameter and 2.12 inches high, near the hole 1 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1.25 inches deep.

One of the backing bolts was started back 1.5 inches.

Fourth shot.—The point of the projectile entered and remained in the plate, presenting an appearance of being welded therein, the end of the chamber being level with the face of the plate. The base and body of the projectile were broken into many small fragments.

The estimated penetration of the point was 7.32 inches.

A bulge was formed on the face of the plate 13.75 inches in diameter. Near the head of the projectile the metal of the plate was dished in and scarcely distinguishable from that of the projectile remaining in the plate. A few radial hair cracks were in the bulge, of varying lengths, none over 6 inches, and a few pieces of metal were scaled off in the bulge.

The bulge on the back of the plate was nearly imperceptible, but was found to be 17 inches in diameter and 0.31 inch high.

No cracks.

There was a discoloration of the backing opposite the back bulge, but ho indent.

Fifth shot.—Projectile: 8-inch Firminy armor-piercing shell of 210 pounds.

The projectile entered the plate and rebounded to the front 38 feet, then ricochetted violently against the timber protection of the gun, rebounding therefrom 6 feet. The projectile cracked longitudinally and flaked considerably at the rear of the head. On the body of the shell was a score which extended around the projectile at the section of a plane inclined to the axis. This score could have been formed by a rotary motion against a hard point, combined with a movement forward and back, and possibly was so done by the rotation of the projectile on entering and rebounding from the plate. The projectile was shortened 1.36 inches, and expanded at the bourrelet 0.31 inch, at the body 0.41 inch, at the base 0.03 inch.

The penetration of the point was 12.87 inches.

A bulge was formed on the face of the plate 17 inches in diameter, with the fringe around the hole chipped off and nowhere higher than 0.94 inch, and a number of radial hair cracks in the bulge, none over 7 inches long.

A through crack extended through hole No. 1 to the top of the plate, 14 inches from the left upper corner, and another through hole No. 3 to the bottom of the plate, 17.5 inches from the left lower corner.

The bulge on the back of the plate was 23 inches in diameter and 2.62 inches high about a hole 0.5 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded to the back bulge and was 15 inches in diameter and 2 inches deep.

The course of backing next to the plate was split in line of backing bolts. The lugs of the lower side-plate clamp were cracked and the left side plate was moved 0.25 inch to the left.

When the plate was removed from the backing it held together, and all the bolts were easily unscrewed excepting four, one above and one below No. 5 hole, and one at upper and one at lower left corner.

This plate gave decidedly the best results of any of the series. As compared with those of trial No. 7, the average penetrations were 2.03 inches less for the Holtzers, and 3.63 inches for the Firminy projectiles, the back bulges being 1.33 and 2.88 inches less in height. The through cracking was almost identical in the two plates. The right side of this plate illustrates the remarkable degree of face hardness which the Harvey treatment is capable of imparting to a plate when properly treated, the Holtzers being shattered, and their heads welded to the plate in a manner similar to that of brittle Pallisers when used against hard-faced compound armor.

Had the left side of the plate received the same treatment as the right side, it would have been an ideal 10½-inch armor plate; but through some evident lack of uniformity in treatment, the left side did not possess the face hardness necessary to break up the projectile on impact; and, as most of the striking energy of shots Nos. 1 and 3 was expended on the plate, that side was so weakened that it cracked at the fifth round. The plate held together when removed from the backing, the greatest height of back bulge was 2 inches, and all but four of the bolts were capable of being unscrewed. The back bulges of shots Nos. 2 and 4 were practically nothing, and the plate was in a condition to afford good resistance to still further attack.

The first conclusion to be drawn from the results of these trials is, that all those plates containing alloy of nickel were superior to the two unalloyed ones; the next point brought out is the increased efficiency of a high over a low grade of steel containing an alloy of nickel; and, lastly, that the plates treated by the Harvey process were placed in order of merit above those of a similar type untreated.

This latter quality was not very marked in the plates made by Carnegie, Phipps & Co., the results of trials Nos. 3 and 4 showing the superiority of No. 4 to have been only slightly attributable to the face hardness, while it was not apparent in comparing trials Nos. 5 and 6. But in the plates manufactured at Bethlehem, where a different method of tempering is used, the face hardness of the Harvey-treated plates was very evident, as shown by the superiority of trial No. 2 over No. 1, and especially by that of No. 8 over the untreated plate of No. 7.

In short, the results of the trials showed that the most efficient type of steel armor is that which contains a moderately high percentage of carbon for producing hardness, nickel alloy for toughness, and is treated for face hardening to resist first impact of a. p. projectiles. The plate best fulfilling these conditions was the high-carbon, nickel-steel, Harveyized plate, manufactured by the Bethlehem Iron Company.

IV.—BEST ARMOR PLATE OF THE YEAR.

In reviewing the year's production of nickel-steel armor plates, we find France represented by the 10.43 inch Creusot plate, tested at Gâvres, July 11, 1891; England by the 10½-inch Cammell plate, tested on board the *Nettle*, January 12, 1892; and the United States by the 10½-inch Bethlehem plate, tested at Indian Head, November 14, 1891.

The severity of the attack on the French and American plates was the same up to the fourth shot; and the results attained, an average penetration of 14.35 inches and one through crack for the French, and an average penetration of 9.58 inches with no cracks for the American plate, place the latter higher in order of merit.

As compared with the English representative nickel-steel plate, also, the American plate ranks higher. Both plates being composed of a homogeneous mass, the severity of penetration attack is indicated by the striking energy employed in each trial compared with that just necessary to perforate a wrought-iron plate of the same thickness; or, as 1.35 to 1.50 in favor of the English plate. In spite of this, the greatest 6-inch penetration in each plate was the same, while the effect of two of the Holtzers was less on the American plate than that of the two Pallisers on the English plate, which was also through-cracked at the fourth shot, the American plate being then without cracks.

We, therefore, find the year's nickel-steel armor represented by the Bethlehem plate, tested November 14, 1891, and the compound type by the Cammell plate, privately tried August 27, 1891. An exact comparison of the two plates is impossible on account of the difference in size, velocity, and quality of projectiles, and also of lack of information regarding the extent of penetrations and bulges of the compound plate. Naturally an official trial takes precedence over a private one, and so far as official record is concerned, the Bethlehem plate is the best production of the year.

But it is interesting to study these two plates of different types, and see where the superiority of either one lies.

The compound plate broke up all three of the a. p. projectiles, but at the cost of considerable scaling around the holes and several face cracks in each case. The face of this plate was very hard, and the weld of the face and back appears to have been good; but even then the superiority of a homogeneous mass, when possessing sufficient tenacity, is well illustrated by the absence of scaling and cracks in the nickel-steel plate after the fourth round of a much more severe attack. Had the striking energies been as great in the English plate as in the American, and only a. p. projectiles been used, it seems more than probable that the great defect of compound armor, that of face scaling, would have developed to a serious extent between shots Nos. 1 and 3. Again, the right side of the nickel-steel plate shows the possibility of imparting a degree of face hardness to a nickel-steel plate fully equal to, or exceeding, any that has yet been attained on a compound plate, while it produced results far exceeding anything shown by the compound plate.

The penetrations of the soft side of the nickel-steel plate were sufficient to produce fissures on the back bulges, but this was also accomplished with an a. p. and a Palliser projectile to such an extent on the compound plate that it seems questionable whether, if the conditions of attack had been equal, the soft-iron back would not have yielded more than it did. The left face of the nickel-steel plate was too soft and the plate depended upon its resistance as a mass to arrest the projectile; whereas, with the compound plate, the hard face seems to have been perforated, and, had the striking energy been increased by the additional 300 foot tons employed against the American plate, it is doubtful whether the soft-iron back would have limited the total penetration to that shown by the nickel-steel plate.

Plate for plate, when the severity of attack and character of projectile are considered, the showings after the fourth shots of the nickel-steel plate, with its two greater penetrations, were much better than those of the compound plate, with its face cracks and scalings; and this, combined with the manner in which the nickel-steel plate absorbed the total striking energy of 4,989 foot-tons of the fifth shot at the expense of only two cracks, while only the part of the 2,696 foot-tons of the fifth shot at the compound plate which was absorbed by it produced a noticeable bulge with fissures, and developed several face cracks, places the Bethlehem plate in order of merit above the Cammell plate, and proves it to be the best armor plate produced during the year.

Type for type, these, the two best representative plates yet manufactured, bring out the points wherein the superiority of a nickel-steel plate, properly treated and face-hardened, over a compound plate exists. The uniformity of face hardness was more marked in the compound than in the nickel-steel plate, but shots Nos. 2 and 4 represent the perfection of results attainable with the latter type. The Holtzers were totally destroyed, no cracks of any kind were developed, and the back bulges were almost imperceptible, averaging 0.28 inch in height. The plate retained its life, all the bolts on that side being easily unscrewed, and, practically speaking, it was uninjured by the attack it had sustained.

While the compound plate was sufficiently hard to shatter the a. p. projectiles, the weakness of employing a soft-iron back is shown by the greater amount of bulging with an attack of less severity; but the greatest weakness of the compound type—the weld—is illustrated by the tendency to face scaling; while the advantage claimed for the use of a non-homogeneous mass, that of not through cracking, seems better provided for by the use of nickel alloy in a homogeneous mass of steel, which not only resisted through, but also face cracking.

Summing up the above results, we find that a homogeneous mass of steel, of a sufficiently high grade of carbon, when combined with a certain percentage of nickel, for imparting tenacity, admits of an equal degree of face-hardening as compound armor, and thus possesses its best quality—that of resisting penetration on impact—without embodying its weaknesses of weld and soft back.

The slight damage that would have been inflicted on the frames of a vessel armored with the Bethlehem high carbon, nickel-steel, Harveyized plate can be appreciated by an inspection of Plate XVIII.

Additional United States Trials.

Two very interesting firing-trials have lately been conducted at the Indian Head Proving Ground. The results prove conclusively the value of employing an alloy of nickel in steel, and also that when the Harvey process is properly employed it is capable of increasing the efficiency of nickel-steel armor to a wonderful degree of perfection.

The performance of the latter plate has never been equaled in the history of armor.

United States reception-test 14-inch nickel-steel.

A reception test of 14-inch nickel-steel armor was conducted at the Indian Head proving grounds, May 22, 1892. It is particularly interesting as being the first trial on record of nickel-steel armor of so great a thickness.

The plate represented the 14-inch diagonal armor, made at the Bethlehem Iron Works, for the battle-ship *Indiana*, and was attacked by three 10-inch a. p. projectiles. Following are some of the data of the trial: (See Plate XIX.)

Reception test of a Bethlehem 14-inch nickel-steel plate.

Date of trial: May 22, 1892, at Indian Head.

Details of plate: 10 feet by 6 feet by 14 inches, backed by 3 feet of oak backing.

Ballistical details.

[Gun used, 10-inch B. L. R.]

Projectile:		
Firth a. p., first and second shots	pounds	500
Carpenter a. p., third shot	do	500
Striking velocity	f. s.	1,390
Striking energy	f. t.	6,697
Striking energy as compared with that just necessary to perforate a wrought-iron plate of same thickness:		
De Marre		1.04
Gâvres		1.06

Firing details.

First shot (Firth a. p. projectile).—Point of impact on centre vertical line of plate, 29 inches from top. The projectile penetrated 14 inches and rebounded 35 feet, shortened 1.42 inches, bourrelet increased .16 and body .2 inch in diameter; small pieces scaled off. Impact smooth, with several fine cracks in it. Body of plate not cracked. Front bulge, 1 inch high and 20 inches in diameter. Regular fringe, 2 inches high.

Second shot (Frith a. p. projectile).—Point of impact, 28¼ inches from right edge, and 29 inches from bottom. Projectile penetrated 13.8 inches, and rebounded 45 feet with its head broken off through bourrelet, with fine cracks in body. Bourrelet increased 0.03, and body 0.11 inch in diameter. Impact smooth with several fine cracks in it. Body of plate not cracked. Front bulge 1 inch high and 20 inches in diameter. Regular fringe from 1 to 2 inches high.

Third shot (Carpenter a. p. projectile).—Point of impact, 29 inches from left and bottom edges. Projectile penetrated 13 inches and rebounded, shortened 1.23 inches, and increased 0.38 inch at bourrelet and 0.53 inch at body, just in rear of bourrelet. Bulge and fringe like those of previous rounds. Plate not cracked.

This plate was not face hardened by any process, but was simply a nickel-steel plate tempered in the ordinary manner. The attack for penetration was not severe, being only 6 per cent greater than that required to perforate wrought iron of equal thickness (using the Gâvres formula as preferable for large calibres and low velocities). The plate showed excellent homogeneity, and the absence of cracks from the battering attack of such large projectiles, with comparatively low velocity, prove it to have possessed great elasticity and tenacity.

Upon the results of this trial the lot was accepted.

The other trial was of a 10½-inch nickel-steel plate manufactured and treated at the Bethlehem Iron Works, and subjected to a most severe information test at Indian Head Proving Grounds. Following are the data of this trial (see Plate XX):

Trial of a 10½-inch nickel-steel, Harveyized plate, manufactured by the Bethlehem Iron Company.

Date of trial: July 23, 1892, at Indian Head.

Details of plate: 8 feet, by 6 feet 2 inches, by 10½ inches, secured by an oak backing 3 feet thick, in the same manner as in the preceding Indian Head trials. Weight 9.33 tons.

Ballistical details.

Gun: 8-inch B. L. R., L/35 calibres.		
Charge: Du Pont's brown prismatic powder	pounds	70
Projectile: Holtzer a. p	pounds	250
Striking velocity	f. s.	1,700
Striking energy	f. t.	5,008
Striking energy per ton of plate, about	f. t.	537
Striking energy as compared with that just necessary to perforate a wrought-iron plate of the same thickness		1.63
Total striking energy of five projectiles	f. t.	25,040

Firing details.

First shot (impact at the centre of the plate).—The projectile was smashed on the plate in an irregular circular form 11 inches in diameter. Depth of deepest cavity, 1¼ inches below surface of plate. There was a circular discoloration 30 inches in diameter around the impact. The plate was not cracked or started in any way. All nuts and bolts were found to be tight.

Second shot (impact 23 inches from top and 23 inches from left edge of plate).—The projectile broke up on the plate, leaving an irregular circular impact similar to that of the first round. The plate was not cracked or started. Some of the wedges of the side plates were loosened, and were driven up before the next shot.

Third shot (impact 22 inches from the top and 23 inches from the right edge of plate).—The point of the projectile penetrated to a depth of 13 inches from face of plate, opening a star crack at the bottom of the hole ¼ to ½ inch wide. The interior of hole was very smooth. The plate was cracked through to the top and side and a slight front bulge raised. The shell rebounded entire 16 feet to the rear, then spun off to the right side 5 feet from target. Its bourrelet was increased in diameter .01 inch, the body swelled to 8.39 inches, an increase of .48 inch, and the length reduced .91 inch. No armor bolts were started; everything remained unmoved. The side-plate wedges were again loosened and set up.

Fourth shot (impact 23 inches from bottom and 23 inches from right edge).—The projectile penetrated to a depth of 13 inches from face of plate, opening ¼ inch star cracks at the bottom of a very smooth hole. It then rebounded 70 feet, landing on a cast-iron gun bed, on which it stood upright, spinning on its point for about one minute. It was shortened 1.03 inches, bourrelet not increased in diameter, body swelled to 8.57 inches, an increase of .61 inch. The plate was not cracked or started in any way.

Fifth shot (impact 23 inches from bottom and 23 inches from left edge).—The projectile broke up on the plate, leaving an impact similar to those of rounds Nos. 1 and 2. The plate was not cracked or started in any way.

Back of plate.

The back of the plate is in excellent condition. Shots 1, 2, and 5 have back bulges 11 inches across, with a maximum height of .75 inch; shots 3 and 4 have regular back bulges 18 inches across and 2.5 inches high with star cracks. The backing has depressions to match the bulges. All armor bolts are intact.

This plate was treated for face-hardening in an improved furnace, one of the objects of which was to lessen the time of treatment, and thus the cost.

The degree of face-hardness imparted to the left side of the plate was remarkable, the recovered fragments of the projectiles indicating that the penetrations of rounds 1, 2, and 5 could not have exceeded 3 inches. A notable feature of these rounds was that the plate remained cold close up to impact, while the impact itself was heated sufficiently to make water boil. This indicates that the total energies of these shots were expended on the projectiles, thus proving that the face was sufficiently hard to break up the Holtzers at the instant of impact.

As with the Bethlehem Iron Company's high-carbon, nickel-steel, Harveyized plate tested November 14, 1891, one side of this plate showed lack of uniformity in tempering, the penetrations of rounds 3 and 4 being each 13 inches. The nickel, however, stood up to its work at these two rounds, and the plate remained in excellent condition. It successfully withstood a total striking energy of 25,040 f. t., or 2,682.6 f. t. per ton of plate, without perforation; two of the back bulges were 2.5 inches high, while three did not exceed 0.75 inch; and the cracks were confined to one corner, which was held in place by its bolts.

The attack was the severest ever held in the history of armor, and the results show this nickel-steel plate, face-hardened by the Harvey process, to be the best armor plate that has ever been produced.

In concluding this article, reference is made to the following table, which includes the principal data of the best results obtained in the United States during the past three years and marks the progress made each year.

The Creusot nickel-steel plate carried the day in 1890; in 1891 a nickel-steel plate face-hardened by the Harvey process gave much better results; and in 1892 the improvements in developing this face treatment have resulted in producing a plate such that had it been perfectly uniform it would have been an ideal armor plate.

Year of trial.	Manufacturer.	Type of armor.	Dimensions of plate.	Weight of plate.	Total striking energy.
				Pounds.	f. t.
1890..	Creusot................	Nickel-steel............	8 ft. by 6 ft. by 10½ in....	20, 679	16, 945
1891..	Bethlehem Iron Co ...	Nickel-steel Harveyized	8 ft. by 6 ft. by 10½ in....	20, 682	16, 945
1892..	......do		8 ft. by 6.17 ft. by 10½ in.	20, 908	25, 040

ROUND No. 1.

Year.	Projectile.			Striking energy (f. t.).			Penetration.	Backing indent.	No. of cracks in plate.	Effect on projectile.
	Type.	Calibre.	Weight.	Total.	Per ton of plate.	Per inch of circumference.				
		Inches.	*Pounds.*				*Inches.*	*Inches.*		
1890..	Holtzer.	6	100	2,989	324	158	*13.75	5.25	None.	Broken.
1891..	...do	6	100	2,989	324	158	12	1.5	None.	Broken.
1892..	...do	8	250	5,008	537	200	†3	†.75	None.	Broken.

ROUND No. 2.

1890..	Holtzer.	6	100	2,989	324	158	*15.6	4.75	None.	Intact.
1891..	...do	6	100	2,989	324	158	0.82	None.	None.	Broken.
1892..	...do	8	250	5,008	537	200	†3	†.75	None.	Broken.

ROUND No. 3.

1890..	Holtzer.	6	100	2,989	324	158	*12.75	3.50	None.	Intact.
1891..	...do	6	100	2,989	324	158	12.25	1.25	None.	Cracked.
1892..	...do	8	250	5,008	537	200	13	2.50	Two..	Set up.

ROUND No. 4.

1890..	Holtzer.	6	100	2,989	324	158	*14.25	3.50	None.	Broken.
1891..	...do	6	100	2,989	324	158	7.32	None.	None.	Broken.
1892..	...do	8	250	5,008	537	200	13	2.50	None.	Set up.

ROUND No. 5.

1890..	Firth ...	8	210	4,989	540	199	*15.75	10.50	None.	Broken.
1891..	...do	8	210	4,989	540	199	12.87	2	Two..	Cracked.
1892..	Holtzer.	8	250	5,008	537	200	†3	†.75	None.	Broken.

* About. † Not more than —.

VIII.

SOME STANDARD BOOKS ON PROFESSIONAL SUBJECTS.

List prepared by Lieut. G. W. MENTZ, U. S. Navy.

Officers and others are requested to inform the Office of Naval Intelligence of any standard works on professional subjects, of recent date, which are not mentioned in the following list.

Foreign books, newspapers, and periodicals may be obtained from B. F. Stevens, 4 Trafalgar Square, Charing Cross, London. From B. F. Stevens' advertising circular "new books are charged at trade prices, which are usually 25 per cent off the price of publication." "Book postage to America is only one-half penny for every 2 ounces up to 4 pounds weight."

"The discount off publication price is about equivalent to the cost of freight or postage, and commission; hence, in making purchases of new books it is safe to estimate that the books would be received at a cost of 25 cents to the shilling (publication price), exclusive of duty, if any."

Remittances to B. F. Stevens, 4 Trafalgar Square, Charing Cross, London, may be made in sterling by banker's drafts, or post-office orders on London, or in American currency at $5 to the pound sterling, this being 25 cents to the shilling. For odd amounts send postage stamps. New York agents, Tice & Lynch, 45 William street.

ARMOR.

DEVELOPMENT OF ARMOR FOR NAVAL USE. By Lieut. E. W. Very, U. S. Navy. Published in the proceedings of the U. S. Naval Institute, Vol. IX, No. 3; whole No. 25. 1883. Can be purchased of the Secretary of the U. S. Naval Institute, Annapolis, Md. Price, $1.

ARMOR AND ITS ATTACK BY ARTILLERY. 1887. By Charles Orde Browne, Captain late Royal Artillery, Lecturer on Armor to the Royal Artillery College, Woolwich. Printed by Royal Artillery Institution. Published by Messrs. Dulau & Co., 37 Soho Square, London, W. C. Book brings the subject up to that date.

The two above works and Chapter VI of General Information Series, No. X, by Lieut. Southerland, U. S. Navy, and Chapter VI of General Information Series, No. XI, by Ensign Simpson, U. S. Navy, contain a complete history of the Development of Armor.

THE PRESENT POSITION OF BRITISH AND FOREIGN ARMOR. 1891. By Capt. C. Orde Browne, late R. A. (Lecturer on Armor to the Royal Artillery College). Price 1*s*. Published in the United Service Magazine, February, 1891. Page 464 *et seq.* Offices of Magazine, 15 York street, Covent Garden, W. C., London.

NOTES ON ARMOR AND ARMOR TRIALS are contained in the General Information Series of the Office of Naval Intelligence, beginning with the year 1886 and continuing in successive numbers.

GENERAL INFORMATION SERIES—

No. V, 1886, page 239 *et seq.* Edition exhausted.

No. VI, 1887, page 322 *et seq.* Edition exhausted.

No. VII, 1888, page 380 *et seq.* Armor and Armor-Piercing Projectiles. Edition exhausted.

No. VIII, 1889, Distribution of Armor, pages 81 to 135, give a graphic history of armor protection and distribution on war vessels. Pages 424 to 427, Notes on armor.

No. IX, 1890, page 132 *et seq.* Armor and armor protection.

No. X, Chapter VI. The Armor question in 1891.

No. XI, Chapter VI.

These numbers have been furnished to ships' libraries as well as to the officers of the Navy.

COMPASSES.

ADMIRALTY MANUAL FOR THE DEVIATIONS OF THE COMPASS. 1882. By F. J. Evans, R. N., F. R. S., superintendent of the Compass Department of the Admiralty, and Archibald Smith, M. A., F. R. S., late Fellow of Trinity College, Cambridge. Price $1.60. May be obtained from storekeeper at Naval Academy. Published by order of the Lords Commissioners of the Admiralty. London, 1882. Sold by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Price 4*s*. 6*d*. Supplied to U. S. ships' libraries. Text-book at Naval Academy. Fifth edition.

ELEMENTARY MANUAL FOR THE DEVIATIONS OF THE COMPASS IN IRON SHIPS. 1889. By F. J. Evans, K. C. B., F. R. S., Captain, R. N. Seventh edition. Price $1.68. May be obtained from storekeeper at Naval Academy. Text book at Naval Academy. Published by J. D. Porter, London, 1889, 31 Poultry and 11 King street, Tower Hill. Price $1. Arranged in a series of questions and answers, intended for the use of seamen, adjusters of compasses, and navigation schools, and as an introduction and companion to the Admiralty Manual for the Deviations of the Compass. Revised and with an appendix by E. W. Creak, Staff Commander, R. N., F. R. S. Supplied to U. S. ships' libraries.

FINDING THE ERROR OF THE MARINE COMPASS ON BOARD SHIP. 1875. By B. F. Greene, Professor of Mathematics, U. S. Navy, Superintendent of Compasses, Bureau of Navigation, Navy Department. Price $2.50. Printed by Government Printing Office. Supplied to U. S. ships' libraries.

THE MATHEMATICAL THEORY OF THE DEVIATIONS OF THE COMPASS. 1879. By J. A. Howell, Commander, U. S. Navy. Printed by the Government Printing Office, Washington, D. C. Arranged for the use of the cadets at the U. S. Naval Academy. Supplied to U. S. ships' libraries.

NAVAL PROFESSIONAL PAPERS, NO. 13. MAGNETISM, ITS GENERAL PRINCIPLES AND SPECIAL APPLICATION TO SHIPS AND COMPASSES. 1883. Bureau of Navigation, Navy Department. Printed by Government Printing Office, Washington, D. C. Supplied to U. S. ships' libraries.

NAVAL PROFESSIONAL PAPERS, NO. 17. MAGNETISM OF IRON AND STEEL SHIPS. 1884. By T. A. Lyon, Lieutenant-Commander, U. S. Navy. Bureau of Navigation, Navy Department. Printed by Government Printing Office, Washington, D. C. An explanation of the various ways in which it affects compasses. Supplied to U. S. ships' libraries.

NAVAL PROFESSIONAL PAPERS, NO. 22. COMPASS DISTURBANCE IN IRON SHIPS. Being second part of No. 22. 1887. By Lieut. C. C. Cornwell, U. S. Navy, Superintendent of Compasses, Bureau of Navigation, Navy Department. Printed by Government Printing Office, Washington, D. C. A lecture delivered at the U. S. Naval War College, September, 1886. Supplied to U. S. ships' libraries.

CIRCULAR NO. 45. DIRECTIONS FOR THE USE OF THE U. S. NAVY COMPENSATING BINNACLE. 1890. Bureau of Equipment, Navy Department. Printed by the Government Printing Office, Washington, D. C. Supplied to U. S. ships' libraries.

PRACTICAL GUIDE FOR COMPENSATION OF COMPASS WITHOUT BEARINGS. By Lieut. Collet, French navy, tutor in the Polytechnic School of France. Translated by W. Bottomley, with a preface by Sir William Thomson, LL.D., etc., professor of natural philosophy in the University of Glasgow, etc. Price 3*s.* 6*d.* Griffin & Co., 2, The Hard, Portsmouth, England.

CHRONOMETERS.

NOTES ON THE MANAGEMENT OF CHRONOMETERS AND THE MEASUREMENT OF MERIDIAN DISTANCES. By Charles F. N. Shadwell, esq., C. B., Captain R. N. Price 5*s.* New edition, carefully revised. London: J. D. Potter, 31 Poultry and 11 King Street, Tower Hill.

LA MARCHE ET LA CONDUITE DES CHRONOMETRES, APRES LES TRAVEAUX DE MM. CASPARI LIEUSSOU, DE MAGNÆ, ETC. 1882. Par Fulgence Legal, lieutenant de vaisseau. Price 1 franc 50 centimes. Paris: Berger-Levrault et Cie., 5 Rue des Beaux-Arts.

NAVY SCIENTIFIC PAPERS, NO. 6. CHRONOMETER RATES AS AFFECTED BY CHANGE OF TEMPERATURE AND OTHER CAUSES. 1887. By Lieut. Commander C. H. Davis, jr., U. S. Navy, in charge of chronometers at the Naval Observatory, Bureau of Navigation, Navy Department. Washington: Government Printing Office. 1877. May be obtained by Naval Officers, from the Bureau of Equipment. Published also as an appendix to Washington Observations.

ELECTRICITY AND MAGNETISM.

PRACTICAL ELECTRICITY. 1889. By W. E. Ayrton, F. R. S., associate member of the Institution of Civil Engineers; Professor of Applied Physics at the City and Guilds of London Central Institution. Price, $2.50. Cassel & Company, limited, London, Paris, New York, and Melbourne. Also by W. J. Johnston Company, Times Building, New York. A laboratory and lecture course for first-year students of electrical engineering, based on the practical definitions of the electrical units. With numerous illustrations. Fourth edition.

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REPRINT OF PAPERS ON ELECTROSTATICS AND MAGNETISM. 1884. By Sir William Thompson, D. C. L., Professor of National Philosophy at the University at Glasgow. London: Macmillan & Co. Second edition.

ELECTRICITY IN THEORY AND PRACTICE, OR THE ELEMENTS OF ELECTRICAL ENGINEERING. By Lieut. Bradley A. Fiske, U. S. Navy. Price, $2.50. The W. J. Johnston Co. limited, 167–177 Times Building, New York. Also by D. Van Nostrand, 23 Murray street and 27 Warren street, New York. Griffin and Co., 2 The Hard, Portsmouth, England. Price, 10*s.* Cloth. 270 pages, 180 illustrations.

L'ÉLECTRICITÉ APPLIQUÉE À L'ART MILITAIRE. 1889. Par le Colonel Gun. Price, 3 francs 50 centimes. Paris, librairie J.-B. Baillière et fils, rue Hautefeuille, 19, près du boulevard Saint-Germain. Avec 140 figures dans le texte.

L'ÉCLAIRAGE ÉLECTRIQUE À LA GUERRE. 1889. Par Rodolphe Van Wetter, lieutenant d'artillerie de l'armée belge. Prix, 7 francs 50 centimes. Paris, G. Carre, libraire-éditeur, rue Saint André des Arts, 58. Madrid, Fuentes y Capdeville, 7 Plaza de Santa Anna. Rome, Turin, Florence, H. Loescher, libraire-éditeur. Gravures dans le texte et atlas de dix-sept planches.

ELECTRICITÉ EXPÉRIMENTALE ET PRATIQUE. 1889 and 1890. Par H. Leblond, agrégé des sciences physiques (Bibliothèque du marin). Price, 26 francs. Published by Berger-Levrault et C^ie^, 5 rue des Beaux-Arts, Paris. 3 volumes in-8°, avec figures et planches, broché, chacun à 6 francs.

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Cours professé à 'Ecole des torpilleurs.

LEÇONS SUR L'ÉLECTRICITÉ, 1890. Gérard (Eric), directeur de l'Institut électrotechnique Montefiore. Price, 20 francs. Published by Gauthier-Villars et fils, 55, Quai des Grands-Augustins, Paris.

Deux volumes grand in-8, se vendent séparément:

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The following works, published and for sale by the W. J. Johnston Company, limited, 167-177 Times Building, New York:

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TREATISE ON ELECTRICITY AND MAGNETISM. By Maxwell. Price, $8. 2 vols. 20 plates. 105 illustrations. Second edition.

AN ELEMENTARY TREATISE ON ELECTRICITY. 1881. By Maxwell. Edited by William Garmet, M. A. Price, $1.90. Oxford: Clarendon Press. Cloth. 208 pages. 6 plates. 54 illustrations.

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NOTES ON ELECTRICITY AND MAGNETISM. 1881. By J. B. Murdock. Price, 60 cents. Also published by Macmillan & Co., New York, (Proceedings of U. S. Naval Institute.) Designed as a companion to S. P. Thompson's Elementary Lessons. Cloth. 139 pages. 38 illustrations.

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ELECTRIC LIGHT INSTALLATION AND MANAGEMENT OF ACCUMULATORS. By Salamons. Price, $1.50. London: Whittaker & Co., 1891. Sixth edition, revised and enlarged. Cl., 99 illustrations, 348 pages.

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EXPLOSIVES.

THE MODERN HIGH EXPLOSIVES. 1884. By Manuel Eissler, mining engineer. Price, ——. To be purchased of John Wiley & Sons, 15 Astor Place, New York. Nitroglycerine and dynamite, their manufacture, their use, and their application to mining and military engineering; pyroxoline or gun cotton; the fulminates, picrates, and chlorates. Also the chemistry and analysis of the elementary bodies which enter into the manufacture of the principal nitro-compounds.

SERVICE CHEMISTRY. 1889. By Vivian B. Lewes, F. I. C., F. C. S., professor of chemistry, Royal Naval College, Greenwich: associate of the Institution of Naval Architects, etc., illustrated. Price 15*s*. Published in London by W. B. Wittingham & Co., 91 Gracechurch street, and 44 and 45 Charterhouse Square, E. C. Chapters XIV to XVI, inclusive, devoted to explosives. Being a short manual of chemistry and its application to the naval and military services.

TRAITÉ THÉORIQUE ET PRATIQUE DES EXPLOSIFS MODERNES ET DICTIONNAIRE DES POUDRES ET EXPLOSIFS. 1889. By Paul F. Chalon, ingénieur des arts et manufactures. Price 25 francs. Publishers, E. Bernard et Cie, 71, rue La Condamine; 53, Quai des Grands-Augustins. 1 vol. in-8 de 506 pp., avec 162 fig. dans le texte. Seconde édition.

RESEARCHES ON EXPLOSIVES, FIRED GUNPOWDER. 1888. By Capt. Noble (late R. A.), F. R. S., etc., and F. A. Abel, C. B., F. R. S., etc. Published by the United States Artillery School Press.

SUBMARINE MINES AND TORPEDOES AS APPLIED TO HARBOR DEFENSE. 1889. By John Townsend Bucknil, London, Offices of Engineering, 35 and 36 Bedford street. [See under Submarine Mines.] Chapter VI of this work, under the title of "Examination of the Different Explosives," gives short descriptions of the principal ones as far as known up to date, 1889, their composition, intensity, advantages for submarine mines, etc.

A HANDBOOK ON MODERN EXPLOSIVES. 1890. By M. Eissler, mining engineer and metallurgical chemist, author of Modern High Explosives, etc. Published by Crosby Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill. This is a practical treatise on the manufacture and application of dynamite, gun cotton, nitroglycerine, and other explosive compounds, including the manufacture of collodion cotton.

HIGH EXPLOSIVES IN WARFARE. 1891. By Commander F. M. Barber, U. S. Navy. Published in The Journal of the Franklin Institute, vol. CXXXI, No. 782, February, 1891, No. 2, pages 117 *et seq.*, Philadelphia. Dr. Wm.

H. Wahl, secretary of the institute. A lecture delivered November 28, 1890, before the Franklin Institute.

HANDBOOK OF GUNPOWDER AND GUN-COTTON. 1888. By Maj. Gen. W. H. Wardell, late Royal Artillery. Price, 2s. 6*d.* Printed by order of the Secretary of State for War. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., or Adam & Chas. Black, North Bridge, Edinburgh, or Hodges, Figgins & Co., 104 Grafton street, Dublin.

PROFESSIONAL PAPERS OF THE CORPS OF ENGINEERS, U. S. ARMY. NO. 23. REPORT UPON EXPERIMENTS AND INVESTIGATION TO DEVELOP A SYSTEM OF SUBMARINE MINES FOR DEFENDING HARBORS OF THE UNITED STATES. 1881. Submitted to the Board of Engineers by Lieut. Col. Henry L. Abbott, Corps of Engineers, Brevet Brigadier General, U. S. Army, Member of the Board. Washington, Government Printing Office.

A DICTIONARY OF EXPLOSIVES. 1889. By Maj. J. P. Cundill, Royal Artillery. Printed by W. & J. Mackay & Co., Chatham. Published by the Royal Engineers Institute, Chatham. Agents, W. & J. Mackay & Co., Chatham, Kent. Also sold by Hamilton, Adams & Co., London.

MÉMORIAL DES POUDRES ET SALPÊTRES, publié par les soins du service de poudres et salpêtres avec l'autorisation du ministre de la guerre. Prix pour un an (4 fascicules); Paris et départements, 12 francs; Union postale, 13 francs. Published by Gauthiers Villars et fils, 55, Quai des Grands-Augustins, Paris. Grand in-8, trimestriel.

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HYGIENE.

OUTLINES OF NAVAL HYGIENE. By John D. McDonald, M. D., F. R. S. Price, 12*s.* 6*d.* Griffin & Co., 2 The Hard, Portsmouth, England. With illustrations.

MANUAL OF PRACTICAL HYGIENE. By E. A. Parkes, M. D. Price, 18*s.* Griffin & Co., 2 The Hard, Portsmouth, England. Fifth edition.

A TREATISE OF HYGIENE AND PUBLIC HEALTH. 1879. Edited by Albert H. Buck, M. D., Instructor in Otology in the College of Physicians and Surgeons, New York, etc. New York: William Wood & Co. Two volumes.

Traité d'Hygiène Navalé. 1877. Par J.-B. Fonssagrives, médecin en chef de la marine, en retraite, professeur à la Faculté de Montpellier, etc. Paris, J.-B. Baillière et fils, 19, Rue Hauteville; Tindall & Cox, King William's street, London. Deuxième edition. 145 figures intercaleés dans le texte.

Traité d'Hygiène Militaire. 1874. Par G. Morache, médecin-major de première classe, professeur agrégé à l'École d'application de médecine et de pharmacie militaire. Paris, J.-B. Baillière et fils, 19, Rue Hauteville.

International Health Exhibition, London, 1884. The Health Exhibition Literature. Vol. X. General Hygiene. Published by William Clowes & Sons, limited, 13 Charing Cross, S. W.

General Hygiene. By Geo. Rohe, M. D.

INTERNATIONAL LAW, ETC.

Introduction to the Study of International Law. 1891. By Theodore D. Woolsey. Price $2.50. Published by Charles Scribner's Sons, 1891. Text-book at the U. S. Military Academy. Designed as an aid in teaching and in historical studies. Sixth edition, revised and enlarged by Theo. S. Woolsey.

Military Law. 1886. By Lieut. Col. W. Winthrop, Deputy Judge-Advocate-General of the U. S. Army; author of the Annotated Opinions of the Judges-Advocate-General. Published by W. H. Morrison, law bookseller and publisher, Washington, D. C. Text book at the U. S. Military Academy. Two volumes.

A Treatise on the Constitutional Limitations which rest upon the Legislative Power of the States of the American Union. 1883. By Thomas M. Cooley, LL. D., one of the justices of the supreme court of Michigan, and Jay professor of law in the University of Michigan. Published by Little, Brown & Co. Fifth edition, with considerable additions giving the results of the recent cases.

Treaties and Conventions Concluded between the United States of America and other Powers since July 4, 1776. 1889. Compiled by John H. Haswell, Chief of the Bureau of Indexes and Archives of the Department of State. Washington: Government Printing Office. May be obtained by applying to Department of State. Containing notes with references to negotiations preceding the several treaties, to the executive, legislative, or judicial construction of them, and to the causes of the abrogation of some of them; a chronological list of treaties; and an analytical index.

The Constitution of the United States. 1882. By George W. Paschal, LL. D., author of Paschal's Annotated Digest. A Treatise on Charitable Uses, Digest of Decisions, etc. Price $3. Washington, D. C.: William H. Morrison, publisher, importer, and stationer. Defined and carefully annotated, with an appendix, supplement, and index thereto.

Elements of International Law. 1880. By Henry Wheaton, LL. D., Minister of the United States at the Court of Prussia; corresponding member of the Academy of Moral and Political Sciences in the Institue of France; honorary member of the Royal Academy of Sciences at Berlin, etc. Second English edition, edited with notes and an appendix of statutes and treaties bringing the work down to the present time. By A. C. Boyd, esq., LL. D. (Camb.), J. P., barrister at law, of the Inner Temple, and midland circuit, author of the "Merchant Shipping Laws." London: Stevens & Sons, 119 Chancery Lane, law publishers and bookseller.

Manual of International Law for the use of Navies, Colonies, and Consulates. 1884. By Jan Helenus Ferguson, Minister of the Netherlands in China; formerly of the Netherland Royal Navy and Colonial Service. Two volumes. London: W. B. Whittingham & Co., 91 Gracechurch street. Also by Martinus Nyhoff, The Hague; and Noronha & Co., Hongkong.

Chronology and Analysis of International Law. 1889. By Wm. Percy Pain, LL. D. (University of London), barrister at law, of the Inner Temple. London: Digby & Long, publishers, 18 Bouverie street, Fleet street, E. C. The chief rules which now govern or formerly have regulated the intercourse of states are given in this work in a condensed form.

International Law. 1887. By Henry Sumner Maine, K. C. S. I., late Master of Trinity Hall, Cambridge, and Member of the Indian Council. London: John Murray, Albemarle street, a series of lectures delivered before the University of Cambridge.

Declaration of War. 1889. By Douglas Owen, of the Inner Temple, barrister at law, secretary of the Alliance Marine Assurance Company, limited, and the Association of Average Adjusters of Great Britain. Author of Marine Insurance Notes and Clauses. London, Stevens & Sons, limited, law publishers and booksellers, 119 and 120 Chancery Lane. A survey of the Position of Belligerents and Neutrals with relative considerations of Shipping and Marine Insurance during the War.

A Treatise on International Law. 1890. By William Edward Hall, M. A. Third edition. Oxford, at the Clarendon Press.

A Treatise upon the Law of Extradition. 1888. By Sir Edward Clarke, Knt., Her Majesty's solicitor-general, formerly Tancred student of Lincoln's Inn. London, Stevens & Haynes, law publishers, Bell Yard, Temple Bar. Third edition. With the conventions upon the subject existing between England and foreign nations, and the cases decided thereon.

International Law. 1888. With Materials for a code of International Law. By Leone Levi, F. S. A., F. S. S., of Lincoln's Inn, barrister at law, professor of commercial law, in King's College, London, doctor of political economy of the University of Tubingen, etc. International Scientific Series, published by D. Appleton & Co., New York.

Wharton's International Law Digest, 1887. Three volumes. Second edition.

Andrews's Manual of the Constitution of the United States. Price 95 cents. Apply to storekeeper, U. S. Naval Academy. Text book at Naval Academy.

Marine International Law. 1885. By Commander Henry Glass, U. S. Navy. Price $1. Published in the proceedings of the U. S. Naval Institute, Vol xi, No. 3, whole No. 34. 1885. To be obtained from the secretary of the U. S. Naval Institute, Naval Academy, Annapolis, Md. Compiled from various sources.

Outlines of International Law. 1887. By George B. Davis, U. S. Army, assistant professor of law at the United States Military Academy. New York, Harper & Bros., Franklin Square. With an account of its origin and sources and of its historical development.

A Handbook of Public International Law. 1885. By T. J. Lawrence, M. A. LL. M., Deputy Whewell, professor of international law in the University of Cambridge; lecturer on international law at the Royal Naval College, Greenwich; late fellow and tutor of Downing College, Cambridge; author of "Some Disputed Questions in Modern International Law." Cambridge: Deighton, Bell & Co. London: George Bell & Sons.

COMMENTARIES UPON INTERNATIONAL LAW. 1874–1885. By Sir Robert Phillimore, D. C. L., member of Her Majesty's most honorable privy council and judge of the high court of admiralty. Four volumes: Vol. I, 1879, third edition; Vol. II, 1882, third edition; and Vol. III, 1885, third edition; Vol. IV, 1874, second edition.

INTERNATIONAL LAW: PRIVATE AND CRIMINAL. 1883. By Dr. L. Bar, professor in the University of Göttingen. Translated, with notes, by G. R. Gillespie, B. A., Oxon., advocate. Boston: Soule & Bugbee.

BELLIGERENT RIGHT ON THE HIGH SEAS SINCE THE DECLARATION OF PARIS. 1856. By Sir Travers Triss, D. C. L., F. R. S., member of the Institute of International Law and one of Her Majesty's council. Price, half a crown. London: Butterworths, 7 Fleet street, law publishers to the Queen's Most Excellent Majesty.

THE NAVIGATION LAWS OF THE UNITED STATES. 1886. Bureau of Navigation, Treasury Department. Washington: Government Printing Office.

LE DROIT INTERNATIONAL THÉORIQUE ET PRATIQUE. 1881. Par M. Charles Calvo, ancien ministre, membre correspondant de l'Académie des sciences morales et politiques de l'Institut de France, de l'Académie royale d'histoire de Madrid, membre fondateur de l'Institut du droit international, etc. Paris, Guillemin et Cie., éditeurs; 14 Rue Richelieu; E. Thorn, éditeur, 7, Rue Médicis; G. Pedone Lauriel, éditeur, 13, Rue Soufflot; A. Rousseau, éditeur, 14, Rue Soufflot, 1881. Troisième édition complète. Four volumes. Précédé d'un exposé historique des progrès de la science du droit des gens.

AN INTRODUCTION TO THE CONSTITUTIONAL LAW OF THE UNITED STATES. 1888. By John Norton Pomeroy, LL.D., author of Lectures on International Law in Time of Peace. Boston and New York: Houghton, Mifflin & Co., the Riverside Press, Cambridge. 1888. Tenth edition, revised and enlarged, by Edmund H. Bennett, LL.D., Dean of the Boston University Law School, especially designed for students, general and professional.

A TREATISE ON THE LAW OF EVIDENCE. 1883. By Simon Greenleaf, LL.D., Fourteenth edition, revised, with large additions. By Simon Greenleaf Croswell. Boston: Little, Brown & Co. Three volumes.

THE LAW AND PRACTICE OF UNITED STATES COURTS-MARTIAL. 1867. By A. A. Harwood, U. S. Navy. New York: D. Van Nostrand, 192 Broadway.

ORDER OF PROCEDURE IN NAVAL GENERAL COURTS-MARTIAL. By M'Lane Tilton, U. S. Marine Corps. Washington: Printed by Powell & Ginck. 1874. Contains also order of procedure for naval summary courts-martial and naval courts of inquiry, compiled from various orders, regulations, and instructions, which have been issued from time to time from the Navy Department and from other sources, for the convenience of novitiating judge-advocates.

NAVAL SUMMARY COURTS-MARTIAL. 1891. Compiled and arranged by Lieut. S. C. Lemly, U. S. Navy, and Lieut. F. L. Denny, U. S. Marine Corps, February 1, 1891. Price 50 cents. Published by the Army and Navy Register Publishing Company, 1420 Pennsylvania avenue, Washington, D. C.

THE PRINCIPLES OF THE LAW OF EVIDENCE, WITH ELEMENTARY RULES FOR CONDUCTING EXAMINATION AND CROSS-EXAMINATION OF WITNESSES. 1882. By W. M. Best, A. M., LL. B. American edition (from seventh

English edition). By Charles F. Chmberlayne, of the Boston Bar. Boston: Soule & Bugbee, law publishers, 37 Court street. Used at Harvard Law School.

Compilation of Laws relating to the Navy, Marine Corps, etc., from the Revised Statutes and Subsequent Acts to March 3, 1883. 1883. Prepared by John W. Hogg, and published by authority of the Navy Department. Washington: Government Printing Office.

MACHINERY.

ENGINES, BOILERS, FUEL, ETC.

Marine Propellers. 1891. By Sidney W. Barnaby, M. I. N. A., and Assoc. M. Inst. C. E., gold medallist of the Institution of Civil Engineers. Price 10*s*. 6*d*. E. and F. N. Spon, 125 Strand, London. New York: 35 Murray street. Third edition entirely rewritten and greatly enlarged. In demy 8vo, cloth, with illustrations.

SYNOPSIS OF CONTENTS.

Chapter I. *First Principles.*—Reaction dependent on mass of water acted on and acceleration imparted in all propellers—Theories of Rankine, Greenhill, and Fitz Gerald—Theoretical limits of efficiency—Causes of loss of work.

Chapter II. *The Paddle-wheel.*—Comparative efficiency of paddle and screw—Approximate rules for area, number, and size of floats of radial and feathering wheels—Average revolutions and slip.

Chapter III. *The Screw.*—Definitions—Slip, positive and negative—Explanations of negative slip in screws of expanding and uniform pitch—Measurement of pitch—Introduction of the screw—Screws of various types—Woodcroft, Dundonald, Griffiths, Mangin, Hirsch, Rigg, Thornycroft propellers described—Antispire—Position of screws—Immersion—Vibration—Effect of inclined shaft—Racing—Effect on steering—Steering screws—Auxiliary screws—Flat-bladed screws—Screws for tugs, electric launches, torpedos—Twin, overlapping, and tripple screws.

Chapter IV. *Experiments with models and their application to the determination of the most suitable dimensions.*—How to experiment with models—Method of making models—Description of dynamometric apparatus—Plotting results of experiments—Disk area and revolutions constants—How to use constants to design screws for any given horsepower, speed of ship, and number of revolutions, and how to estimate efficiency—How to correct for different values of wake, propulsive coefficients and number of blades—Comparative efficiency of fine and coarse pitch ratios—Mr. Froude's work—Comparative advantage of large and small screws—Screws for cargo ships—Table of constants for disk area and revolutions—Table of wake factors—Examples in the use of tables.

Chapter V. *Geometry of the Screw.*—Complete directions, with diagrams, for drawing a screw—*a*, of uniform pitch; *b*, with screw blades; *e*, with expanding pitch—Strength of blades—Bolting of blades to boss—Twisting of blades in boss and effect on pitch.

Chapter VI. *The Hydraulic Propeller.*—Fleischer, Ruthven, and Thornycroft systems described—Relative efficiency of centrifugal pump and screw as a propeller—How to measure the efficiency of a hydraulic propeller.

Chapter VII. *The Screw-turbine Propeller.*—Description—Efficiency—Adaptability for light-draft vessels.

A Manual of Marine Engineering. 1886. By A. E. Seaton, lecturer on marine engineering to the Royal Naval College, Greenwich, etc. Price, 18*s*. Charles Griffin & Co., 2 The Hard, Portsmouth, England. Ninth edition—comprising the designing, constructing, and working of marine machinery, with numerous tables and illustrations reduced from working drawings.

The Marine Steam Engine. 1885. By Richard Sennett, Chief Engineer Royal Navy, etc., and late instructor to marine engineering at the Royal Naval College. Price, 21*s*. London: Longmans, Green & Co. Also Griffin & Co., 2 The Hard, Portsmouth, England. Text Book Naval Academy. May be purchased from the storekeeper N. A. Price, $5.62.

A treatise for the use of engineering students and officers of the Royal Navy. Numerous diagrams.

A MANUAL OF THE STEAM ENGINE AND OTHER PRIME MOVERS. 1882. By William John Macquorn Rankine, civil engineer, etc.; late regius professor of civil engineering and mechanics in the University of Glasgow, etc. Price, 12*s*. 6*d*. Third edition, revised by W. J. Miller, C. E., secretary Inst. Engineers and Shipbuilders in Scotland. London: Charles Griffin & Co., Exeter street, Strand. Griffin & Co., 2 The Hard, Portsmouth, England. Numerous engravings, folding plate, and a diagram of the mechanical properties of steam.

A TREATISE ON STEAM BOILERS; THEIR STRENGTH, CONSTRUCTION, AND ECONOMICAL WORKING. 1879. By Robert Wilson, C. E., late inspector for the Manchester Steam Users' Association for the prevention of steam-boiler explosions and for the attainment of economy in the application of steam. London: Crosby, Lockwood & Co., 7 Stationers' Hall Court, Ludgate Hill. Fifth edition.

A MANUAL OF RULES, TABLES, AND DATA FOR MECHANICAL ENGINEERS. 1878. By Daniel Kinnean Clarke, member of the institution of Civil Engineers. London: Blackie & Son, Paternoster Building. Based on the most recent investigations; of constant use in calculations and estimates relating to strength of materials and of elementary constructions, labor, heat and its applications, steam and its properties, combustions and fuels, steam boilers, steam engines, gas engines, flow of air and of water, air machines, hydraulic machines, mill gearing, friction and the resistance of machinery, etc., weights, measures, and moneys, British and foreign, with the reciprocal equivalents for the conversion of British and French compound units of weights, pressure, time, space, and money, etc. Second edition.

STEAM BOILER EXPLOSIONS, IN THEORY AND IN PRACTICE. 1887. By R. H. Thurston, A. M., Doc. Eng. Director of the Sibley College, Cornell University. Author of a History of the Steam Engine; Stationery Steam Engines; Materials of Engineering, etc. New York, John Wiley & Sons. Well illustrated.

A TEXT BOOK ON STEAM AND STEAM ENGINES. 1887. By Andrew Jamieson, principal and professor of engineering, College of Science and Arts, Glasgow; member of the Society of Telegraph Engineers and Electricians; member of the Institute of Civil Engineers; fellow of the Royal Society, Edinburgh; joint author of Electrical Rules, Tables, and Formulæ. London: Charles Griffin & Co., Exeter street, Strand. Second edition. With numerous diagrams, four folding plates, and examination questions. Specially arranged for the use of science and art, City and Guilds of London Institute, and other engineering students.

TRIPLE EXPANSION ENGINES AND ENGINE TRIALS. 1890. By Prof. Osborne Reynolds, LL. D., F. R. S., M. Inst. C. E. With an abstract upon the discussion of the paper. Edited by F. E. Idell, M. E., New York: D. Van Nostrand Company, 23 Murray street and 27 Warren street.

ELEMENTARY MECHANISM. By Arthur T. Woods, assistant engineer, U. S. Navy, member of the South American Society of Mechanical Engineers; assistant professor of mechanical engineering, Illinois State University, Champaign, Ill., and Albert W. Stahl, assistant engineer, U. S. Navy, member of the American Society of Mechanical Engineers; professor of mechanical engineering, Purdue University, La Fayette, Ind. New York: D. Van Nostrand, publishers, 23 Murray street. A text book for students of mechanical engineering.

On the elementary relation between Pitch, Slip, and Propulsive Efficiency. 1878. By W. Froude, Esq., M. A., F. R. S. Published in "Transactions of the Institution of Naval Architects," which are sold by Henry Sothern & Co., 36 Piccadilly, London, W. Read at the nineteenth session of the Institution of Naval Architects, April 11, 1878.

On the Minimum Area of Blade in a Screw Propeller Necessary to form a Complete Column. 1878. By James H. Cotterill, M. A., F. R. S. Published in "Transactions of the Institution of Naval Architects," which are sold by Henry Sothern & Co., 36 Piccadilly, London, W. Read at the nineteenth session of the Institution of Naval Architects, April 11, 1878.

Boilers, Marine and Land: Their Construction and Strength. 1890. By Thomas W. Traill, F. E. R. N., Member of the Institute of Civil Engineers, Engineer-in-Chief to the Board of Trade, etc. Second edition. With Illustrations. London: Charles Griffin & Co., Exeter Strand. A Handbook of Rules, Formulæ, Tables, etc., relative to Material, Scantlings, and Pressures, Safety Valves, Springs, Fittings and Mountings, etc., for the use of Engineers, Surveyors, Draftsmen, Boiler-Makers, and Steam Users.

Thermodynamics of the Steam Engine and other Heat Engines. 1889. By Cecil H. Peabody, Associate Professor of Steam Engineering, Massachusetts Institute of Technology. New York: John Wiley & Sons, 15 Astor Place.

The Steam Engine Considered as a Thermodynamic Machine. 1890. By James H. Cotterill, M. A., F. R. S., Professor of Applied Mechanics in the Royal Naval College. F. & E. & F. N. Spon, 125 Strand, London. New York: 12 Courtland street. Second edition. Revised and Enlarged. A Treatise on the Thermodynamic Efficiency of Steam Engines; illustrated by Diagrams, Tables, and Examples from Practice.

A Manual of Steam Boilers: Their Design, Construction, and Operation. 1888. By R. H. Thurston, M. A., Doc. Eng.; Director of Sibley College, Cornell University; Past President American Society of Mechanical Engineers, etc. New York: John Wiley & Sons, Astor Place. For Technical Schools and Engineers.

Tables of the Properties of Saturated Steam and other Vapors. 1888. By Cecil H. Peabody, B. S., Assistant Professor of Steam Engineering in the Massachusetts Institute of Technology. New York: John Wiley & Sons.

Valve gears. By H. W. Spangler, New York: John Wiley & Sons.

Fuels; Solid, Liquid, and Gaseous. 1891. By H. J. Phillips, F. C. S., Analytical and Consulting Chemist to the Great Eastern Railway, etc. Lockwood & Sons, London, 1891, 7 Stationers' Hall Court, Ludgate Hill. Their Analysis and Valuation for the use of Chemists and Engineers.

Steam Boiler Construction. 1891. By Walter S. Hutton, Civil and Mechanical Engineer. London: Crosby, Lockwood & Sons, 7 Stationers' Hall Court, Ludgate Hill. A Practical Handbook for Engineers, Boiler-Makers, and Steam Users, containing a large Collection of Rules and Data relating to recent Practice in the Design, Construction, and Working of all kinds of Stationary, Locomotive, and Marine Steam Boilers. Three hundred illustrations.

Boiler tests. By Geo. H. Barrus. Price $5. Boston: Gowing & Company, 70 Kilby street. The following is the table of contents:

Part I.—Introduction.

Methods employed in conducting the tests.

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Comparison of boilers which produce saturated steam with those producing superheated steam.

General conditions which secure economy.

Comparison of different kinds of boilers.

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Flue heaters.

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GUIDE PRATIQUE DU CHAUFFEUR ET DU MÉCANICIEN SUR LES BATEAUX TORPILLEURS, rédigé en conformité de la dépêche ministérielle du 15 janvier 1887, par M. E. Clergeay, mécanicien en chef de la marine. Dessins du 2^e maître-mécanicien, C. Deguy. Paris, 1888, un beau vol., in-8, relié; Price 5 francs 50 centimes.

NOUVELLES MACHINES MARINES DES BÂTIMENTS À GRAN VITESSE; DES TORPILLEURS ET DES EMBARCATIONS À VAPEUR. Par Maurice Demoulin, ingénieur des arts et manufactures. Price 40 francs. Paris, E. Bernard et Cie., Quai des Grands-Augustins, 53: Vol. I, text. Vol. II, plates.

LES MACHINES MARINES, COURS PROFESSÉ À D'ÉCOLE D'APPLICATION DU GÉNIE MARITIME. A. F. A. Bienaymé, directeur de l'École d'application du génie maritime. Price of book, complete, 60 francs. Published by E. Bernard & Cie., 53, Quai des Grands-Augustins, Paris. Ouvrage courronné par l'Académie des sciences. L'ensemble de l'ouvrage comprend un volume de texte grand in-4° de 500 pages et un atlas de 162 planches doubles.

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SUPPLÉMENT AUX COURS DU BORDA ET DE L'ÉCOLE D'APPLICATION. MACHINES AUXILIAIRIES EN USAGE SUR LES BÂTIMENTS DE LA FLOTTE. Par P. Guillaume, mécanicien en chef de la marine. Price, book complete, 33 francs. Paris, Challamel aîné, éditeur, Librairie maritime et coloniale, 5, Rue Jacob et Rue Furstenberg, 2, 1887. Also published by E. Bernard et Cie., 53, Quai des Grands-Augustins, Paris. Ouvrage accompagné d'un atlas in-folio de 59 planches gravées.

THE STEAM ENGINE. 1891. By Daniel Kinnear Clark, M. Inst. C. E., M. J. M E., honorary member of the American Society of Mechanical Engineers; author of Railway Machinery; A Manual of Rules, Tables, and Data for Mechanical Engineers; The Exhibited Machinery of 1862; Tramways, their Construction and Working, etc. Price per vol., 12*s.* 6*d.* London, Glasgow, Edinburg, and New York: Blakie & Son, Limited. A treatise on steam engines and boilers, comprising the principles and practice of the combustion of fuel, the economical generation of steam, the construction of steam boilers, and the principles, construction, and performance of steam engines, stationary, portable, locomotive, and marine, exemplified in engines and boilers of recent date. Illustrated by above 1,300 figures in the text and a series of folding plates, drawn to scale. Four volumes, 1,556 pages.

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METALLURGY, CHEMISTRY, ETC.

THE METALLURGY OF STEEL. 1892. By Henry Marion Howe, A. M. (Harvard) S. B. Vol. I. Published by the Scientific Publishing Company. 27 Park Place, New York. Third edition. This book was first published in the Engineering and Mining Journal, commencing 1887. References are given in the book of the authorities used; it would profit most readers to examine them; contains many tables of data. The titles of the eighteen chapters are as follows:

Classification and constitution of steel.
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Iron and silicon.
Iron and manganese.
Iron and sulphur.
Iron and phosphorus.
Chromium, tungsten, copper.
The metals occurring but sparingly in iron.
Iron and oxygen.
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Other volumes not yet out.

ALUMINIUM: ITS HISTORY, OCCURRENCE, PROPERTIES, METALLURGY, AND APPLICATIONS, INCLUDING ITS ALLOYS. 1890. By Joseph W. Richards, M. A., A. C., Instructor in Metallurgy at the Lehigh University. Henry Carey, Baird & Co., Industrial Publishers, Booksellers, and Importers, 810 Walnut street. Second edition; revised and greatly enlarged. Illustrated by twenty-eight engravings and two diagrams. Philadelphia:

THE ART OF ELECTROLYPTIC SEPARATION OF METALS, ETC. (Theoretical and Practical.) 1890. By G. Gore, F. R. S., author of the Art of Electro-Metallurgy; The Theory and Practice of Electro-Desposition; Electro-Chemistry; The Art of Scientific Discovery; The Scientific Basis of National Progress. London: The Electrical Printing and Publishing Company, Limited, Salisbury Court, Fleet street, E. C. New York: The D. Van Nostrand Company, 23 Murray street and 27 Warren street.

ENCYCLOPÉDIE CHIMIQUE. Publié sous la direction de M. Fremy, membre de l'Institut, professeur à l'École polytechnique de professeurs et d'industriels. Cost for all the volumes purchased separately 1,364 francs. Les souscripteurs à l'ouvrage complet, qui s'engagement à prendre toutes les parties dès l'apparition, obtiendront un rabais de 20 pour cent. sur les prix de ces parties séparées. Notamment, le prix des parties parues actuellement est réduit, pour ces souscripteurs, à 1091 francs 20 centimes.

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METEOROLOGY, LAWS OF STORMS, ETC.

WHIRLWINDS, CYCLONES, AND TORNADOES. 1884. By William Morris Davis, instructor in Harvard College. Boston: Lee & Shepard, publishers. New York: Charles Dillingham.

A BAROMETER MANUAL FOR THE USE OF SEAMEN. 1884. Issued by the Authority of the Meteorological Council. London: Sold by J. D. Potter, 31 Poultry, and Edward Stanford, Charing Cross.

A POPULAR TREATISE ON THE WINDS: COMPRISING THE ATMOSPHERE, MONSOONS, CYCLONES, TORNADOES, WATERSPOUTS, HAILSTORMS, ETC. 1889. By William Ferrell, M. A. Ph. D., late professor and assistant in the Signal Service; member of the National Academy of Sciences and of other home and foreign scientific societies. New York: John Wiley & Sons, 15 Astor Place.

ELEMENTARY METEOROLOGY. 1887. By Robert H. Scott, M. A., F. R. S., Secretary to the Meteorological Council and author of Weather Charts and Storm Warnings. London: Kegan Paul, Trench & Co., Paternoster Square. Second edition. Numerous illustrations.

WEATHER CHARTS AND STORM WARNINGS. 1887. By Robert H. Scott, Secretary to the Meteorological Council. London: Longmans, Green & Co. New York: 15 East Sixteenth street. Third edition, revised and enlarged, with numerous illustrations.

WEATHER. 1887. By Ralph Abercromby, Fellow of the Royal Meteorological Society, London; Member of the Scottish Meteorological Society, and author of "Principles of Forecasting by Means of Weather Charts." New York: D. Appleton & Co. A popular exposition of the nature of weather changes from day to day.

PRINCIPLES OF FORECASTING BY MEANS OF WEATHER CHARTS. 1885. By Ralph Abercromby, F. R. Met. Soc. London: Printed for Her Majesty's Stationery Office and sold by J. D. Potter, 31 Poultry, and Edward Stanford, Charing Cross. Second edition.

SEAS AND SKIES IN MANY LATITUDES; OR WANDERINGS IN SEARCH OF WEATHER. 1888. By Ralph Abercromby, Fellow of the Royal Meteorological Society, etc. London: Edward Stanford, 26 and 27 Cockspur street, Charing Cross. Maps and illustrations.

WEATHER FORECASTING FOR THE BRITISH ISLANDS BY MEANS OF A BAROMETER, THE DIRECTION AND FORCE OF THE WIND AND CIRRUS CLOUDS. 1890. By Captain Henry Toynbee, F. R. S., F. R. G. S., F. R. Met. S., Late Marine Superintendent Meteorological Office. London: Edward Stanford, 26 and 27 Cockspur street, Charing Cross.

A BAROMETER MANUAL FOR THE USE OF SEAMEN. 1884. Issued by the authority of the Meteorological Council. Price, 1*s.* 3*d.* London: Printed for Her Majesty's Stationery Office and sold by J. D. Potter, 31 Poultry, and Edward Stanford, Charing Cross.

TEXT BOOK OF OCEAN METEOROLOGY. 1887. By Alex. Geo. Findlay, F. R. G. S. Price, 12*s.* London: Edited by Staff-Commander W. R. Martin, R. N., Lecturer on Meteorology at the Royal Naval College, Greenwich. Price, 12*s.* Published by Richard Holmes Laurie, 53 Fleet street, E. C., London. This book is compiled from the sailing directories for the oceans of the world.

INSTRUCTIONS IN THE USE OF METEOROLOGICAL INSTRUMENTS. 1888. By Robert H. Scott, M. A., F. R. S., director of the Meteorological Office. Price, 2*s.* 6*d.* London: Eyre & Spottiswoode, East Harding street, Fleet street, E. C., or Adam and Charles Black, 6 North Bridge, Edinburgh, or Hoges, Figgis & Co., 104 Grafton street, Dublin. Compiled by direction of the Meteorological Committee.

INSTRUCTIONS FOR OBSERVING CLOUDS ON LAND AND SEA. 1888. By Hon. Ralph Abercromby, F. R. Met. Soc., author of "Principles of Forecasting," "Weather," "Seas and Skies," etc. Price, 18*d.* London: Edward Stanford, Charing Cross, S. W. With photographs and engravings.

ÉTUDES DES MOUVEMENTS DE L'ATMOSPHÉRE. 1890. Par E. Touriner lieutenant de vaisseau. Price, 1 franc, 25 centimes. Broch., in–8. Sold by L. Baudoin et Cie., 30 Rue et Passage Dauphiné.

PHYSICAL GEOGRAPHY OF THE SEA. By Maury. Price, 6*s.* Sold by Griffin & Co., 2 The Hard, Portsmouth, England, also by D. Appleton & Co., New York.

THE BAROMETER, THERMOMETER, HYGROMETER, AND ATMOSPHERIC APPEARANCES AT SEA AND ON LAND AS AIDS IN FORETELLING WEATHER, WITH BRIEF RULES FOR THEIR USE, AND THE PRACTICAL APPLICATIONS

OF THEIR SEPARATE AND COMBINED INDICATIONS AS WEATHER GUIDES. 1869. By Commodore Thornton A. Jenkins, U. S. Navy. Washington: Government Printing Office. Compiled from the latest and most trustworthy authorities.

THE SAILORS' HORNBOOK FOR THE LAW OF STORMS. By Henry Piddington, president of the Marine Courts, Calcutta. Price, 8*s.* 9*d.* London, Frederic Norgate, 7 King Street, Covent Garden. Edinburgh: Williams and Norgate, 20 Frederick Street. Seventh edition. A practical exposition of the theory of the law of storms and its uses to mariners of all classes, in all parts of the world, shown by transparent cards and useful lessons.

AN ATTEMPT TO DEVELOP THE LAW OF STORMS BY MEANS OF FACTS ARRANGED ACCORDING TO PLACE AND TIME, AND HENCE TO POINT OUT A CAUSE FOR THE VARIABLE WINDS, WITH THE VIEW TO PRACTICAL USE IN NAVIGATION. 1850. By Lieut. Col. W. Reid, C. B., F. R. S. (of the Royal Engineers). London: Published by John Weale, Library of Civil, Military, and Mechanical-Engineering, 59 High Holborn. May also be purchased of G. P. Putnam, New York; Little & Brown, Boston. Third edition, illustrated by charts and woodcuts.

THE LAW OF STORMS CONSIDERED IN CONNECTION WITH THE ORDINARY MOVEMENTS OF THE ATMOSPHERE. 1862. By H. W. Dove, F. R. S., member of the Academies of Berlin, Moscow, Munich, St. Petersburg, Vienna, etc. Price, ——. London: Longman, Green, Longman, Roberts, and Green; with diagrams and charts of storms. Second edition entirely revised and considerably enlarged. Translated with the author's sanction and assistance by Robert H. Scott, M. A., Trinity College, Dublin; lecturer in mineralogy to the Royal Dublin Society.

HANDBOOK OF THE LAW OF STORMS. BEING A DIGEST OF THE PRINCIPAL FACTS OF REVOLVING STORMS. By William Radcliff Birt, F. R. A. S., author of the Hurricane and Sailors' Guides, etc. London: George Philip & Sons, 32 Fleet street. Liverpool: Caxton Buildings, South John street and 49 and 51 South Castle street. A new edition with important additions. For the use of commanders in Her Majesty's Navy and the Mercantile Marine.

HANDBOOK OF CYCLONIC STORMS IN THB BAY OF BENGAL. FOR THE USE OF SAILORS. 1890. By John Eliot, M. A., Meteorological Reporter to the Government of India. Price, 5 rupees (about $2.50). Calcutta: Printed by the Superintendent of Government Printing, India. Published by the Meteorological Department of the Government of India.

CYCLONES ET TYPHONS. LOI DES DÉPRESSIONS BAROMÉTRIQUE DANS CES OURAGANS ET SES APPLICATIONS À LA MER. 1890. Par F. Ernest Fournier, capitaine de vaisseau. Price, 75 centimes. Paris: Libraire militaire de L. Baudoin et Cie, 30 rue et Passage Dauphiné. Broch., in-8. Publié avec autorisation du ministre de la marine.

REMARKS ON THE PREVAILING STORMS ON THE ATLANTIC COAST. By W. C. Redfield.

NOTES ON THE FORM OF CYCLONES IN THE SOUTHERN OCEAN. By C. M. Meldrum.

AN INQUIRY INTO THE NATURE AND COURSE OF STORMS IN THE INDIAN OCEAN SOUTH OF THE EQUATOR; WITH A VIEW OF DISCOVERING THEIR ORIGIN, EXTENT, ROTARY CHARACTER, RATE AND DIRECTION OF PROGRESSION, BAROMETRIC DEPRESSION, AND OTHER CONCOMITANT PHENOEMA; FOR THE PRACTICAL PURPOSE OF ENABLING SHIPS TO ASCER-

TAIN THE PROXIMITY AND RELATIVE POSITION OF HURRICANES; WITH SUGGESTIONS ON THE MEANS OF AVOIDING THEM. 1845. By Alexander Thom, Surgeon, Eighty-sixth Royal County Down Regiment. London: Smith, Elder & Co., Cornhill.

NOTES ON THE FORM OF CYCLONES IN THE SOUTHERN INDIAN OCEANS, AND ON SOME OF THE RULES GIVEN FOR AVOIDING THEIR CENTERS. 1873. By C. Meldrum, Esquire, M. A., F. R. A. S., Director of the Government Observatory, Mauritius. Price, 6*d*. London: Printed by Eyre & Spottiswoode, and published by E. Stanford, Charing Cross. Reprinted from the monthly notices of the Meteorological Society of Mauritius.

Besides the above there are a number of pamphlets, monographs, etc., published from time to time by the Hydrographic Office, from which the latest information can be obtained.

THE PILOT CHART OF THE NORTH ATLANTIC OCEAN gives rules for maneuvering in a cyclone. Issued monthly by the Hydrographic Office.

PRACTICAL HINTS IN REGARD TO WEST INDIA HURRICANES. 1889. Translated by Lieutenant G. L. Dyer, U. S. Navy. Hydrographic Office. Not for sale.

HURRICANES; WITH NAUTICAL DIRECTIONS FOR MANEUVERING IN THEM. 1872. Hydrographic Office. Pamphlet.

THE GREAT STORM OFF THE ATLANTIC COAST OF THE UNITED STATES, MARCH 11-14, 1888. 1888. By Everett Hayden, in charge of the Division of Marine Meteorology. Washington: Government Printing Office. Nautical Monograph No. 5, Hydrographic Office.

NAVAL SHIP CONSTRUCTION.

SHIPBUILDING IN IRON AND STEEL. 1869. By E. J. Reed, C. B., chief constructor of the navy, vice-president of the Institution of Naval Architects, and honorary member of the Liverpool Literary and Philosophical Society. London: John Murray, Albermarle street. A practical treatise, giving full details of construction, processes of manufacture, and building arrangements, with results of experiments on iron and steel, and on the strength and water-tightness of riveted work. By order of the Lords Commissioners of the Admiralty the examinations in practical iron shipbuilding of candidates for promotion in Her Majesty's dockyards will be mainly based upon this work.

THE MODERN PRACTICE OF SHIPBUILDING IN IRON AND STEEL. 1886. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture; member of the Institution of Naval Architects; surveyor to Lloyd's Register of Shipping. Price, $2.25. London and Glasgow: William Collins, Sons & Co., limited. May be obtained from the storekeeper at the Naval Academy. Vol. I, text; Vol. II, plates.

A TEXT-BOOK OF NAVAL ARCHITECTURE FOR THE USE OF OFFICERS OF THE ROYAL NAVY. 1889. By J. J. Welch, assistant constructor, royal navy; and instructor in naval architecture at the Royal Naval College, Greenwich. Price, 4*s*. Published by order of the Lords Commissioners of the Admiralty, London. Printed for Her Majesty's stationery office by Darling & Son, limited, 1-3 Great street, Thomas Apostle, E. C. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C.; Adam and Charles Black, 6 North Bridge, Edinburgh; or Hoges, Figgis & Co., 104 Grafton street, Dublin. May be obtained from the storekeeper at the Naval Academy. Price, $1.38.

THEORETICAL NAVAL ARCHITECTURE. 1887. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture, etc. Price, $2.50. New York: G. P. Putnam's Sons, 182 Fifth avenue, or William Collins, Sons & Co., limited, London and Glasgow. Vol. I, text; Vol. II, plates. May be obtained from storekeeper at the Naval Academy. A treatise on the calculations involved in naval design.

A TREATISE ON THE STABILITY OF SHIPS. 1885. By Sir Edward J. Reed, K. C. B., F. R. S., M. P., etc. London: Charles Griffin & Co., Exeter street, Strand. Numerous diagrams and tables.

A MANUAL OF NAVAL ARCHITECTURE. FOR THE USE OF OFFICERS OF THE ROYAL NAVY, OFFICERS OF THE MERCANTILE MARINE, SHIPBUILDERS, SHIPOWNERS, AND YACHTSMEN. 1882. By W. H. White, Chief Constructor, Royal Navy; member of the council of the Institution of Naval Architects; member of the Institution of Civil Engineers; fellow of the Royal School of Naval Architecture; and late instructor in naval architecture at the Royal Naval College. Price £1 4*s*. London: John Murray, Albermarle street. Griffin & Co., 2 The Hard, Portsmouth, England. Second edition, revised and enlarged. The Lords Commissioners of the Admiralty have been pleased to authorize the issue of this book to the ships of the royal navy.

NAVAL ARCHITECTURE: A TREATISE ON LAYING OFF AND BUILDING WOOD, IRON, AND COMPOSITE SHIPS. 1874. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture; member of the Institution of Naval Architects; of the controller of the Navy's Department Admiralty, Whitehall. Charge, 7*s*. 6*d*. for the two volumes. London and Glasgow: William Collins, Sons & Co., limited. Griffin & Co., 2 The Hard, Portsmouth, England. Vol. I, text; Vol. II, plates.

ON A METHOD FOR CALCULATING THE STABILITY OF SHIPS. 1891. By Assistant Naval Constructor D. W. Taylor, U. S. Navy. Price $1. Proceedings of the United States Naval Institute, Vol. XVII, No. 2, 1891, whole No. 58. Apply to secretary of the institute.

NAVAL PROFESSIONAL PAPERS NO. 23. THE RESISTANCE OF SHIPS. 1888. By William Froude, esq., F. R. S. Published by Government Printing Office, Washington. The following subjects are treated in this number, all by the same author except No. 5:

1. Experiments on the resistance of a full-sized ship at various speeds, with H. M. S. *Greyhound*, in 1871.
2. Comparative resistance of long ships of several types. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.
3. Fundamental principles of the resistance of ships.
4 Experiments upon the effect produced on the wave-making resistance of ships by length of parallel middle body. Read at the 18th session of the Institution of Naval Architects, March 23, 1877.
5. Leading phenomena of the wave-making resistance of ships. By R. E. Froude, esq., with discussion. Read at the 22d session of the Institution of Naval Architects, April 8, 1881.
6. Ratio of indicated to effective horse-power, as elucidated by Mr. Denny's M. M. trials at varied speeds. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.

See under Periodicals, "Transactions of the Institution of Naval Architects."

COURS DE CONSTRUCTION NAVALE PROFESSÉ À L'ÉCOLE D'APPLICATION DU GÉNIE MARITIME. 1886. Par. A. Hauser, ingénieur de la marine, chevalier de la Légion d'Honneur, sous-directeur à l'École d'application du génie maritime. Price complete, 80 francs. Paris: E. Bernard et Cie., editeurs, Quai des Grands-Augustins. Vol. I, text; Vol. II, plates.

GUIDE DES CALCULS DE DÉPLACEMENT ET DE STABILITÉ HYDROSTATIQUE DES NAVIRES. 1888. Par Benjamin Martinenq. Price 20 francs. Paris, E. Bernard et C., 53, Quai des Grands-Augustins. Un vol. in-4°, 202 pages, 43 figures et 6 planches.

ARCHITECTURE NAVALE. THÉORIE DU NAVIRE. 1890-1891. By J. Pollard et A. Dudebout, Ingénieurs de la marine: professeurs à l'École du génie maritime. Paris, Gauthier-Villars et fils, imprimeurs-libraires du Bureau des longitudes de l'École polytechnique, Quai des Grandes-Augustins, 55. This is the most complete work on the subject of naval architecture that has ever been written, and probably the most authentic. Four volumes (sold separately).

Volume I. Cacul des éléments géométriques des carènes droites et inclinées. Géometrie du navire. 1890. Price 13 francs.

Volume II. Statique du navire. Dynamique du navire dans le mouvement de roulis en mer calme. 1891.

Volume III. Dynamique du navire dans le mouvement de roulis sur houle. Dynamique due navire dans le mouvement rectiligne horizontal. Résistence des carène. In press.

Volume IV. Dynamique du navire dans le mouvement curviligne horizontal. Propulsion. Vibrations des coques des navires à hélice. In press.

There are many other works on this subject, but they are nearly or entirely obsolete, and Pollard et Dudebout and Hauser about cover the whole ground. The most valuable works of reference are probably the "Transactions of the Institution of Naval Architects," office 5, Adelphi Terrace, London, W. C., and to be obtained from Henry Southern & Co., 30 Piccadilly, London, W. M. Price, £2 5*s*. Published annually. See under "Periodicals" of this list. And "Transactions Northeast Coast Institute of Engineers and Naval Architects," published annually by Andrew Reid Sons & Co., Printing Court Buildings, Akenside Hill, Newcastle-upon-Tyne. London office, 4 Queen's Head Passage, Paternoster Row, E. C. Price, £3 3*s*.

NAVIGATION, SURVEYING, ETC.

THE NEW AMERICAN PRACTICAL NAVIGATOR. Editon of 1889. By Nathaniel Bowditch, LL. D., Bureau of Navigation. Published only by the Navy Department. 8vo.

BOWDITCH'S USEFUL TABLES. 1890. By Nathaniel Bowditch, LL. D., Bureau of Navigation. Published only by the Navy Department. 8vo. New edition.

THE DEVELOPMENT OF GREAT CIRCLE SAILING. 1889. By G. W. Littlehales. Price, $1. Hydrographic Office.

TABLE OF MERIDONAL PARTS FOR THE TERRESTRIAL SPHEROID COMPRESSION $\frac{1}{293465}$. 1889. By G. W. Littlehales and J. S. Siebert, Bureau of Navigation. Hydrographic Office.

NAVIGATION AND NAUTICAL ASTRONOMY. By J. H. C. Coffin, professor of astronomy, navigation, and surveying. D. Van Nostrand, New York. Prepared for the use of cadets at the U. S. Naval Academy. Second edition.

WRINKLES IN PRACTICAL NAVIGATION. 1881. By Capt. S. T. S. Lecky, R. N. R., Fellow of the Royal Astronomical Society; Fellow of the Royal Geographical Society; Extra Master; passed in steam, compass adjustment, etc. Price, 15*s*. London: George Philip & Son, 32 Fleet street,

E. C. Liverpool: Caxton Buildings, South John street, and Atlas Buildings, 49 and 51 South Castle street. Also Griffin & Co., 2 The Hard, Portsmouth, England. With 76 illustrations.

THE PRACTICE OF NAVIGATION AND NAUTICAL ASTRONOMY. By Henry Raper, lieutenant, R. N., F. R. A. S., F. R. G. S. Price, 16*s.* London: Published by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Griffin & Co., 2, The Hard, Portsmouth, England.

AZIMUTH.—A TREATISE ON THIS SUBJECT. 1877. By Joseph Edgar Craig, lieutenant-commander, U. S. Navy. New York: John Wiley & Sons, 15 Astor Place. A study of the astronomical triangle and the effect of errors in the data. Illustrated by loci of maximum and minimum errors.

A PRACTICAL AID TO THE NAVIGATOR. By Lieut. E. W. Sturdy, U. S. Navy. Price, $2. New York: John Bliss & Co. The book is intended simply to assist a practical navigator in finding his position at sea by improved methods given in works on navigation.

NAVIGATION. 1888. By Lieut. Commander Asa Walker, U. S. Navy. Price, $1.35. Baltimore: Isaac Friedenwald. To be obtained from the storekeeper at the U. S. Naval Academy. Prepared as a text-book at the U. S. Naval Academy.

A TREATISE ON NAVIGATION AND NAUTICAL ASTRONOMY. 1888. Compiled by Staff-Commander W. R. Martin, R. N., instructor in nautical surveying, navigation, and compass adjustment; lecturer on meteorology at the Royal Naval College, Greenwich; and formerly Naval Assistant to the Hydrographer. London: Longmans, Green & Co., and New York: 15 East Sixteenth street. Sanctioned for use in the Royal Navy by the Lords Commissioners of the Admiralty.

REPORT ON THE TELEGRAPHIC DETERMINATION OF DIFFERENCES OF LONGITUDE IN THE WEST INDIES AND CENTRAL AMERICA. 1877. By Lieut. Commander F. M. Green, U. S. Navy. Washington: Government Printing Office. Prepared at the U. S. Hydrographic Office (No. 65) by order of Commodore R. H. Wyman, U. S. Navy, Hydrographer. Not for sale. Apply to the U. S. Hydrographic Office or Bureau of Equipment, Navy Department.

TELEGRAPHIC DETERMINATION OF LONGITUDES IN JAPAN, CHINA, AND THE EAST INDIES: EMBRACING THE MERIDIANS OF YOKOHAMA, NAGASAKI. VLADIVOSTOK, SHANGHAI, AMOY, HONGKONG, MANILA, CAPE ST. JAMES, SINGAPORE, BATAVIA, AND MADRAS, WITH THE LATITUDE OF THE SEVERAL STATIONS. 1883. By Lieut. Commander F. M. Greent C. H. Davis, and Lieut. J. A. Norris, U. S. Navy, in 1881 and 1882. No, for sale. Published by the order of Capt. J. G. Walker, U. S. Navy, Chief of the Bureau of Navigation, Navy Department. Washington: Government Printing Office.

REPORT ON THE TELEGRAPHIC DETERMINATION OF LONGITUDES IN MEXICO, CENTRAL AMERICA, AND THE WEST COAST OF SOUTH AMERICA. 1885. By Lieut. Commander C. H. Davis, Lieuts. J. A. Norris and Charles Laird, U. S. Navy. Bureau of Navigation. Not for sale. Furnished by Bureau of Equipment or Hydrographic Office. This contains in one chapter a descriptive treatise on the various methods employed in the exchange of telegraphic time signals over submarine lines.

TRAITÉ DE NAVIGATION. NAVIGATION ASTRONOMIQUE. NOUVELLE NAVIGATION ASTRONOMIQUE. 1887. Theorie par M. Yvon Villaraceau, Astronome de l'Observatoire de Paris, membre de l'Institut et du Bureau des Longitudes. Practique, par M. Aved de Magnac, lieutenant de vaisseau. Theorie et practique, in one volume 4-to, with plates, 20 francs. Volumes sold separately. Theorie 10 francs; practique 12 francs. Paris: Gauthier-Villars, imprimeur-libraire du Bureau des Longitudes de l'Ecole polytechnique, successor de Mallet-Bachlier, Quai des Augustins, 55.

LES NOUVELLES METHODES DE NAVIGATION. 1887. Par A. Ledieu, ancien officer de vaisseau, examinateur de la marine. Prix, 15 francs. Paris: Dunod, editeur-libraire des corps nationnaux des ponts et chaussees, des mines et des telegraphes, Quai des Augustins, 49. Enrichi de nombreusses gravures intercalees dans le texte: renferment tous les nouveaux types calcul pour la determination des droits de hauteur et du point complet a la mer (methods Marcq Saint-Hilaire et Pagel ameliorее procedee semi-logarithmique et semi-arithmetique), ainsi que pour la reduction des distances lunaires et l'usage perfectionne des chronometres, avec application elementaire de la theorie des erreurs d'observation.

REPORT OF THE TELEGRAPHIC DETERMINATION OF LONGITUDE ON THE EAST COAST OF SOUTH AMERICA. 1880. By Lieut. Commander F. M. Green, U. S. Navy. Not for sale. Bureau of Navigation. Furnished by Bureau of Equipment or Hydrographic Office.

HANDY BOOK OF THE STARS USED IN NAVIGATION. HOW TO FIND THEM AND HOW TO USE THEM IN GETTING THE SHIP'S POSITION AND CORRECTION OF THE COMPASS. By Capt. W. B. Whall, younger brother, Trinity House; Extra Master; Author of Handy Book of the Tides. Price, 7*s.* 6*d.* London: George Philip & Son, 32 Fleet street, E. C. Liverpool: Philip, Son & Nephew, 45 to 51 South Castle street.

NAUTICA STIMATA AD USO DEI CAPITANI MARITIMI E DEGLI INSTITUTI NAUTICI. 1891. Per Enrico Fileti, Professore di Astronomia Nautica nel R. instituto Gioeni-Trabia. Palermo: Libreria Internazionale, Carlo Clausen. Con travole e con figure intercalate nel testo.

NAUTICAL SURVEYING. 1890. By the late Vice-Admiral Shortland, LL. D., late fellow of Pembroke College, Cambridge. London and New York: Macmillan & Co. Published by the author's widow and children.

PRACTICAL MARINE SURVEYING. 1889. By Harry Phelps, ensign, U. S. Navy. New York: John Wiley & Sons, 15 Astor Place. Text-Book Naval Academy.

A TREATISE ON PRACTICAL ASTRONOMY AS APPLIED TO GEODESY AND NAVIGATION. 1885. By C. L. Doolittle, Professor of Mechanics and Astronomy, Lehigh University. New York: John Wiley & Sons, 15 Astor Place.

HYDROGRAPHICAL SURVEYING. 1882. By Capt. W. J. L. Wharton, R. N. Price, 15*s.* London: John Murray, Albermarle street. A description of the means and methods employed in constructing charts.

GENERAL INSTRUCTIONS FOR HYDROGRAPHIC WORK. 1883. United States Coast and Geodetic Survey, J. E. Hilgard, Superintendent. Washington: Government Printing Office. Apply to Coast Survey.

CHART AND CHART MAKING. By Lieut. J. E. Pillsbury, U. S. Navy. Proceedings of the U. S. Naval Institute, No. 29.

SPHERICAL AND PRACTICAL ASTRONOMY. By Chauvenet. Apply to storekeeper, Naval Academy.

ICE AND ICE MOVEMENTS IN THE BERING SEA AND ARCTIC BASIN. 1890. By Ensign Edward Simpson. Hydrographic Office.

THE USE OF OIL TO LESSEN THE DANGEROUS EFFECT OF HEAVY SEAS. 1887. Compiled by Lieut. E. B. Underwood, U. S. Navy. Hydrographic Office.

THE SEXTANT AND OTHER REFLECTING MATHEMATICAL INSTRUMENTS. 1891. By F. R. Brainard, U. S. Navy. D. Van Nostrand & Co., New York. Science Series No. 101. Contains 33 illustrations, with practical hints. suggestions, and wrinkles on errors, adjustments, and use of such instruments.

DESCRIPTION ET USAGE DES INSTRUMENTS NAUTIQUES. MINISTERE DE LA MARINE. 1889. Par M. E. Guyon, capitaine de frigate, chef du service des Instruments Nautiques au service hydrographique de la marine. Paris: Imprimerie Nationale.

HANDBUCH DER NAUTISCHEN INSTRUMENTE 1890. Hydrographisches Amt des Reichs-Marine-Amt. Berlin: Ernst Siegfried Mittler und Sohn's, Konigliche Hofbuchhandlung, Kochstrasse, 68-70. Zweite Auflage. Mit 33. Taflen in Steindruck und 171 holzschmitten in text.

ORDNANCE.

AMMUNITION.

TREATISE ON AMMUNITION. 1887. Printed by order of the Secretary of State for War. Price, 6*s*. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., London; or Adam and Charles Black, North Bridge, Edinburg; or Hodges, Figgis & Co., 104 Grafton street, Dublin. Fourth edition, corrected to January 1, 1887.

GUNS.

EXTERIOR BALLISTICS. 1887. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, $1.25. Printed by Isaac Friedenwold, No. 32 South Paca street, Baltimore, Md. Second edition revised and partially rewritten. Prepared and arranged for the use of the cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

INTERIOR BALLISTICS. 1887. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, $1.18. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. A text-book for the use of naval cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

THE ELASTIC STRENGTH OF GUNS. 1885. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, 70 cents. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Prepared and arranged for the use of cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

TEXT-BOOK OF ORDINANCE AND GUNNERY, NAVAL B. L. GUNS. 1887. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, $2.38. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Prepared and arranged for the use of cadets at the U. S. Naval Academy. Second edition revised and partially rewritten. To be obtained from the storekeeper, U. S. Naval Academy.

VELOCITY AND PRESSURE IN GUNS. By Ensign J. H. Glennon, U. S. Navy, Instructor in Ordnance and Gunnery, U. S. Naval Academy. Price, $1. Proceedings of the U. S. Naval Institute.

ACCURACY AND PROBABILITY OF FIRE. 1888. By Ensign J. H. Glennon, U. S. Navy. Price, $1. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Prepared for the use of cadets at the U. S. Naval Academy.

TRAITÉ DE BALISTIQUE EXPÉRIMENTAL. 1884. Par Hélie, professeur à l'École d'artillerie de la marine. Prix, 18 francs. Publié par Gauthiers-Villars et fils, 55 Quai des Grands-Augustins, Paris. Deuxième édition, beaucoup augmentée, avec la collaboration de M. Hugoniot, capitaine d'artillerie de la marine. Deux vol. in-8, avec figures et nombreux tableaux. Ouvrage publié sous les auspicies du ministre de la marine. (Honoré d'un grand prix en 1885 par l'Académie des Sciences.)

NOMENCLATURE OF STEEL B. L. R. GUNS AND CARRIAGES AND MOUNTS FOR HOTCHKISS GUNS. Latest edition, 1890. Printed at the Torpedo Station, Newport. Furnished to ships by Bureau of Ordnance. Edition limited. Contains many plates. The book gives the nomenclature of such guns and carriages only as are used in the U. S. Navy. The names of the parts of the Colt's double-action navy revolver are also given.

MODERN FRENCH ARTILLERY: (THE ST. CHAMOND, DE BANGE, CANET, AND HOTCHKISS SYSTEMS.) *1892. By James Dredge. Price, £2 10s. London: Offices of "Engineering," 35 and 36 Bedford street, Strand, W. C. New York: John Wiley & Sons, 53 East Tenth street. Imperial quarto, handsomely bound in half morocco, 500 pages of text, tables, and plates, and over 700 illustrations. The work is provided with a carefully-prepared and copious index, and also contains many illustrations of French warships.

CHAPTERS.

I.—Introductory.
II.—Steel Ordnance.
III.—Breechloading Mechanism.
IV.—The Present Condition of French Ordnance.
V.—The St. Chamond Steel Works.
VI.—The De Bange System of Ordnance.
VII.—The Forges et Chantiers de la Méditerranée.
VIII.—Hotchkiss Machine and Quick-Firing Guns.
IX.—The French Navy.

CONTENTS.

I.—Artillery in the Crimean War—First Delivery of Armstrong Breechloading Guns—Treuille de Beaulieu System of Breechloading—The Armstrong System of Gun Manufacture—The French Standard Gun of 1851—Earliest Form of French Rifling—French Cast-Iron Reinforced Guns—American System of Breechloading, 1855—Parrot Cast-Iron Ordnance, Reinforced with Steel Hoops—Holley's Opinion of Parrot Guns—Strength of American Cast Iron for Guns—Endurance of English Cast-Iron Guns—The Rodman Gun—Smooth-Bore Guns and the American War—Holley's Opinion of English Guns—Manufacture of Armstrong Guns at Elswick in 1863—Materials used in English Ordnance in 1863—Ranges and Velocities of English Guns, 1863 to 1866—Powder Charges of English and American Guns—The Woolwich and Elswick Gun Factories—Whitworth Guns—Longridge's Wire Guns—The Blakely Gun—The Lionel Thomas Gun—Krupp Guns in 1851—Bessemer Steel Guns—Systems of Rifling: Treadwell, Montigny, Cavalli, Wahrendorf, Whitworth, Armstrong, Prussian, Woolwich, Armstrong's Shunt—Holley's Opinion of Armstrong's System of Shunt Rifling—Brass Studs and Zinc Strips on Projectiles—Expansion Systems of Rifling; Hotchkiss, Lionel Thomas, Blakely—Whitworth Projectiles—Palliser Projectiles—Report of Select Ordnance Committee in 1863 against Breechloading—State Manufacture of Ordnance in France—Removal of Restrictions upon Private Manufacture of Ordnance in France—Progress in the Manufacture in French Ordnance since 1885—French Cast-Iron Guns—French Reinforced Cast-Iron Guns in 1868—French Steel-Lined Cast-Iron

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*Engineering for 1892 contains a series of articles on "Modern United States Artillery," well illustrated, which will probably appear in book form.

Guns—Early French Steel Guns—The Ruelle Ordnance Factory—The Nevers Ordnance Factory—Reilly's Report on French Ordnance in 1863—French Projectiles, 1873—32-Cent. (12.60-in.) French Gun. Type 1870 to 1881—Cost of Cast-Iron Ordnance at Ruelle—Quality of Cast Iron now used in French Ordnance—Present Method of Lining Cast-Iron Guns in France—Particulars of French Reinforced Cast-Iron Guns, 1873—Comparative Efficiency of French, English, and German Guns. 1873—Cost Price of French Cast-Iron Reinforced Ordnance—Cost Price of French Guns of Various Calibers, pages 1 to 13 (illustrated by Figs. 1 to 24).

II.—Modern Types of French Steel Ordnance—Krupp and Armstrong Steel Guns Tested in France—Assailly Steel used for French Guns in 1862—Commencement of the Manufacture of Gun Steel at St. Chamond—The 24-Cent. (9.45 in.) Steel Gun "Marie-Jeanne"—Commencement of the Manufacture of Steel Guns at Creusôt—Firth & Sons Supplying Gun Steel to France—Heavy French Steel Guns, 1875 to 1879—Types of French Artillery, 1881—Maximum Caliber of Modern French Ordance—The Manufacture of Modern French Artillery—Testing Steel used in French Ordnance—Government Tests for Gun Steel used in France—Powder tests for Steel Gun Tubes—Testing Steel Jackets—Lining Tubes for French Steel Guns—Amount of Shrinkage given to Rings and Tubes—Rifling for French Modern Naval and Coast-Defense Guns—Machine for Rifling Heavy Guns—32-Cent. (12-60-in; Gun and Carriage made at Creusôt—Standard Form of French Rifling, pages 14 to 19 (illustrated by Fig. 25 to 38).

III.—Earliest Form of Interrupted Screw Breech-Block; Treuille de Beaulieu, Schenck and Saroni, American, Blakley—Krupp's Wedge Breech-Block—Breech Mechanism for French Naval Guns—Gas Check for French Naval Guns—The De Bange Breechloading Mechanism—Details of De Bange Carrier Ring—De Bange Obturating Primer—United States Modifications of the French System—Standard French System of Breech Mechanism—The Canet System of Breech Mechanism—Canet's Modifications of the De Bange Obturator—Canet's Breechloading Safety appliances—Canet's Breech Mechanism for Heavy Guns—Canet's Breech Mechanism for Quick-Firing Guns—The Woolwich System of Breechloading—Abandonment of Muzzle for Breechloading in England—The Armstrong System of Breechloading in 1862—Modern Conversion of Early Armstrong Breechloading Guns—Report of English Directory of Artillery in Favor of Breechloading. 1878-'79—Special Ordnance Committee of 1879—Adoption of French System of Breechloading in England—The Action of the De Bange Obturator—The Woolwich System of Breech Mechanism for 6-in. Guns—The Woolwich System of Breech Mechanism for 9.2-in. Guns—Electric Firing Device for 9.2-in. Guns, H.M.S. "Impérieuse"—The Armstrong System of Breech Mechanism—The Elswick Cup—Armstrong Breech Mechanism for Quick-Firing Guns—Electric Firing Device for Armstrong Quick-Firing Guns—Armstrong's Breech Mechanism for Heavy Guns—The Krupp System of Breech Mechanism for Field Guns and for Heavy Guns—The Hotchkiss System of Breech Mechanism—The Nordenfelt System of Breech Mechanism for Quick-Firing Guns, pages 20 to 38 (illustrated by Figs. 39 to 116).

IV.—Condition of French Artillery in 1870—French Criticism of the Krupp System—Comparison of Crucible and Cast Steel for Gunmaking—Heavy Krupp Ordnance for Russia—French Criticism of English Ordnance—Manufacturerers of Gun Steel in France—Private Manufacturers of Guns in France—De Bange's Improvements in Ordnance, pages 39 to 41.

V.—History of the St. Chamond Company—Productions—Mode of Manufacturing Gun Steel—Manufacture of Armor Plates—Arrangement of Steel Works—The Assailly Works—The Givors Works—The Works at Boucau—The St. Chamond Company at the Paris Exhibition. 1889—Tests of Steel made in St. Chamond—Projectiles made by the St. Chamond Company—Gun Turrets—Ordnance—The Darmancier Hydraulic Brake—Gun Carriages—The Darmancier System of Gun Construction—The Daudeteau-Darmancier System of Quick-Firing Guns—Types of Naval and Coast Defense Armament—St. Chamond 7.87-in. Naval Gun—-10.82-in. Coast Defence Guns—6.10-in. Naval Gun—St. Chamond Gun Carriages—Armour-Plated Forts made by the St. Chamond Company—French Government Commission for Land Defenses—Mougin's Oscillating Turret for Land Defenses—80-Millimetre (3.15-in.) Mountain Gun—Carriage for 12-Cent. (4.72-in) Gun—Disappearing and Travelling Platform for 4.72-in. Gun—155-Millimetre (6.10-in.) Mortar and Firing Platform—155-Millimetre (6.10-in) Gun and Carriage—Details of the Daudeteau-Darmancier Quick-Firing Gun. Pages 42 to 56 (illustrated by Figs. 117 to 144).

VI.—French Criticism of the De Bange System of Ordnance—De Bange Field and Siege Guns—The De Bange "Frettes Biconiques"—Monthaye's Criticism of Krupp and De Bange—Mariotti's "French and German Guns"—The De Bange 14-in. Gun at the Antwerp Exhibition, 1887—Trials of De Bange 14-in. Gun at Calais—De Bange Guns Manufactured by the Cail Company—French and Foreign Purchasers of De Bange Guns and Carriages—The Cail Company during the Siege of Paris—Guns Exhibited by the

Cail Company at the Paris Exhibition of 1889; De Bange 80-Millimetre (3.15-in.) Mountain Guns; Field Guns, Light and Heavy Pattern; Siege Guns; Coast Defense and Naval Guns; Howitzers and Mortars; 32-Cent. (12.60-in.) Coast-Defense Gun—Tests of 32-Cent. (12.60-in.) De Bange Gun at Calais—The Engström Quick-Firing Gun Manufactured by the Cail Company. Pages 57 to 70 (illustrated by Figs. 145 to 179).

(*The Canet System.*)

VII.—The Forges et Chantiers de la Mediterranée at the Paris Exhibition of 1889—The Canet System of Artillery—Principles of Construction in Canet Guns—Comparison of the Canet with other Guns—Initial Velocities obtained with Canet Guns—Flatness of Trajectory obtained with Canet Guns—Comparison of Dangerous Zones with Krupp and Canet Guns—Modifications Introduced in Gun Design with the use of Smokeless Powder—Guaranteed Velocity in Canet Guns—Comparison of Canet and De Bange Guns—Steel Employed for Gun Making at the Havre Factory of the Forges et Chantiers de la Mediterranée—Particulars of Canet Guns made at Havre—The Construction of Canet Gun Carriages—French Criticism of Krupp Gun Carriages—French Criticism of De Bange Gun Carriages—Testing Gun Steel at the Havre Gun Factory—Strength of Gun Steel before and after Tempering—French Government Specifications of Gun Steel—Inspection of Guns during Construction at the Havre Factory of the Forges et Chantiers de la Mediterranée—Measuring the Bores of Guns before and after Firing; the Star Gauge—Inspection of Breech Mechanism—Firing Tests at the Havre Factory of the Forges et Chantiers de la Mediterranée—Inspection of Guns after Firing Tests—Testing 5.9-in. and 9.45-in. Guns at the Havre Factory—History of the Havre Gun Factory of the Forges et Chantiers de la Mediterranée—Works of the Forges et Chantiers de la Mediterranée—Ordnance made by the Forges et Chantiers de la Mediterranée during the Franco-German War—Mr. G. Canet—Types of Ordnance made at the Havre Gun Factory—Description of the Havre Gun Factory—Canet 66-Ton Guns for the Japanese Government—Testing Department at the Havre Gun Factory—Steel Employed in the Manufacture of Canet Guns—Canet Guns and Gun Carriages supplied to the French and Foreign Governments—Canet Gun Carriages on the French Ironclad "Marceau"—Canet Gun Carriages on the Spanish Armour-Clad "Pelayo"—Canet System of Torpedo Tubes—French and Foreign Purchasers of Canet Torpedo Tubes—The Hoc Polygon of the Forges et Chantiers de la Mediterranée—Necessity of Experiment in Gun Design—The Cost of Firing Trials—Firing Ranges at the Hoc Polygon—Gun Platforms, Traversing Cranes, Proof Chambers, and Cartridge Stores at the Hoc Polygon—Iron Cases for Carrying Cartridges—Relations between the French Government and the Havre Gun Factory of the Forges et Chantiers de la Mediterranée—Method of Recording Gun Tests at the Havre Factory—Comparison between Canet and Armstrong Quick-Firing Guns—Mode of Recording Tests of Gun Carriages at the Havre Factory—Le Boulengé Chronograph—The Peigné Telemeters—Crusher Gauges—The Sébert Velocimeter—Canet Mountain and Field Guns—Principles of Construction in Canet Field Guns—Carriages—Range of Vertical Training—Projectiles for 2.95-in. Canet Mountain Guns—Canet Mountain Guns—Breech Mechanism for Canet Mountain and Field Guns—Breech Mechanism for 75-Millimetre (2.95-in.) Canet Boat Gun—Safety Firing Apparatus—The Lemoine Brake for Mountain and Field Gun Carriages—Canet Hydraulic Brake for Field Gun Carriages—Particulars and Weights for Canet Field Guns—Limbers for Mountain and Field Artillery—Time and Percussion Fuzes—Composition of Field and Mountain Batteries—British Mountain and Field Guns and Carriages—Elswick Mountain Gun and Carriage—Carriage for 12-Pounder British Field Gun—Brake Gear for British Field Gun—Elswick 12-Pounder Field Gun and Carriage—Training Gear for Elswick Field Guns—Elswick Elephant Mountain Gun—Canet Siege and Garrison Guns—Classification of Calibres and Types—Range and Penetration—Mountings for Siege and Garrison Guns—Description of 4.72-in. Canet Siege Gun—Construction of Carriage for 4.72-in. 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Quick-Firing Guns—Training Mechanism for Canet Quick-Firing Guns—Electrically Worked Quick-Firing Guns—Latest Developments in Canet Quick-Firing Guns—Electrically Worked Naval Turrets—Safety and Firing Devices for Canet Quick-Firing Guns—Automatic Sighting Devices for Canet Quick-Firing guns—Penetrating Powers of Canet Quick-Firing Guns—Trajectory—Ammunition Hoists—Gun Carriages—English Service 9-in. 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VIII.—Origin of Machine Guns—The Gatling Gun—Types of Revolving Guns used in France—Construction of Hotchkiss Revolving Gun—Methods of Loading, Firing, and Extracting the Cartridges of the Revolving Gun—The Hotchkiss Field and Naval Revolving Gun—Methods of Mounting—Hotchkiss Flank-Defense Gun—Projectiles for Flank-Defense Gun—37-Millimetre (1.46-in.) Naval Revolving Gun—37-Millimetre Revolving Field Gun and Carriage—47-Millimetre (1.85-in.) Naval Gun and Carriage—53-Millimetre (2.09-in.) Naval Gun and Carriage—Ammunition for Hotchkiss Revolving Guns—Ballistical Efficiency and Penetrating Power—Summary of Firing Trials—Firing Trials with Flank-Defense Gun—The Hotchkiss Quick-Firing Gun—Materials Employed in its Construction—Comparison of the Hotchkiss and other Systems—Various Calibres of Hotchkiss Quick-Firing Guns—Details of Construction—The 37-Millimeter (1.46-in.) Quick-Firing Gun—Field Carriage for 37 Millimetre Quick-Firing Gun—47 and 57-Millimetre (1.85-in. and 2.24-in.) Quick-Firing Guns and Field Carriages—47-Millimetre Quick-Firing Gun and Carriage for Naval Service—57, 65, and 75-Millimetre (2.24-in., 2.56-in., and 2.95-in.) Guns for Naval Service—Mountings for Hotchkiss Quick-Firing Guns—The Hotchkiss Recoil Mount—Naval Mounting for 6-Pounder and 9-Pounder Guns—Embrasure Mounting—Field and Mountain Carriages for Hotchkiss Quick-Firing Guns—Ammunition for Hotchkiss Quick-Firing Guns—Details of 65-Millimetre (2.56-in.) Hotchkiss Quick-Firing Gun and Carriage—Hotchkiss 33-Pounder Quick-Firing Gun—Naval Mount for 33-Pounder Quick-Firing Gun—The Hotchkiss 12-Cent. (4.72-in.) Quick-Firing Gun—Mountings for a 3-Pounder and 37-Millimetre (1.46-in.) Quick-Firing Gun—Hotchkiss Field and Mountain Gun Equipment—12-Pounder Mountain Gun and Carriage—Description of Field Carriage for Hotchkiss Quick-Firing Gun—Ballistical Efficiency of Hotchkiss Quick-Firing Guns—Trials in France, England, and Italy—Penetration of Hotchkiss Quick-Firing Guns—Firing Tables for Hotchkiss Quick-Firing Guns—Tabulated Results of Experiments with Hotchkiss Quick-Firing Guns—The Hotchkiss and Creusôt Systems of Armored Forts—Armored Fort for 15-Cent. (5.90-in.) Gun—Field and Traveling Forts for Quick-Firing Guns—Creusé de la Touche System of Armoured Forts—Mechanism for Training Quick-Firing Guns in Forts—Creusé de la Touche System of Traveling Forts—The Hotchkiss-Schneider System of Armor-Clad Forts with Disappearing Gun Mounts—Fort with Disappearing Mount for 53-Millimetre (2.09-in.) Gun, 295 to 359 (Illustrated by Figs. 537 to 706).

IX—Summary of Ships in the French Navy—Ironclads with Guns in Barbette Turrets—Ironclads with Central Batteries—Ironclad Battery Ships—Armored Cruisers (First

Group)—Armored Cruisers (Second Group)—Coast-Defense Turret Ships—Armored Gunboats (First Class)—Armored Gunboats (Second Class)—Unarmored Ships—Battery Cruisers—Barbette Cruisers (First Class)—Barbette Cruisers (Second Class)—Barbette Cruisers (Third Class)—Torpedo Cruisers—Dispatch Boats (First Class)—Dispatch Boats (Side Wheels) (First Class)—Dispatch Boats (Second and Third Class)—Torpedo Dispatch Boats—Transport Dispatch Boats—Gunboats—Sea-going Torpedo Boats—First-Class Torpedo Boats—Second-Class Torpedo Boats—Third-Class Torpedo Boats, etc.—Transports—First-Class Transports—Second-Class Transports—Third Class Transports—The "The Jauréguiberry," Line-of-Battle Ship—The "Marceau," Line-of-Battle Ship—The "Hoche" Line-of-Battle Ship—The Barbette Ironclad "Formidable"—The Barbette Ironclad "Amiral Bauin"—The Barbette Ironclad "Amiral Duperré"—Particulars of First-Class Barbette Ironclads—The Central Battery Ironclad "Colbert"—The Central Battery Ironclad "Trident"—The Central Battery Ironclad "Devastation"—The Central Battery Cruiser "Redoubtable"—The Central Battery Ironclad "Richelieu"—The Armored Cruiser "Turenne"—The Armored Cruiser "Triomphante"—The Armored Cruiser "Duguesclin"—The Twin-Screw Armored Gunboat "Achéron"—The Armored Gunboat "Fusée"—The First-Class Cruiser "Cécille"—The Unarmored Battery Cruiser "Sfax"—The Unarmored Cruiser "Davout"—The Unarmored Cruiser "Milan"—The Unarmored Barbette Cruiser "Forbin"—French Criticism of Third-Class Cruisers—Third Class Cruisers—The Torpedo Cruiser "Condor"—The Sea-going Torpedo Boats "Dragonne" and "Fléche"—The Sea-going Torpedo Boat "Ouragon"—Pages 363 to 433.

The Spanish Cruiser "Pelayo"—Page 436.

Index, Pages 439 to 458.

MODERN UNITED STATES ARTILLERY. 1892. A series of articles, well illustrated, in engineering for 1892. London: Offices of Engineering, 35 and 36 Bedford street, Strand.

GENERAL INFORMATION SERIES:

No. V, pages 211 *et seq.*

No. VI, Chap. IV. 8-inch B. L. R. for the U. S. Navy, and notes, pages 297 *et seq.*

No. VII, pages 336 *et seq.*

No. VIII, Chap. IV. Development of the high-power gun. Chap. V. Naval gunnery, and notes, pages 375 *et seq.*

No. IX, pages 73 *et seq.*

No X, Chap. III.

No. XI, Chap. III.

RAPID-FIRE GUNS.

THE NEWEST FACTOR IN NAVAL WARFARE. 1891. By W. Laird Clowes. Price, 1*s*. Published in the United Service Magazine for February, 1891. To be obtained from the International News Company, New York.

UNITED STATES PATENT SPECIFICATIONS. Price, 25 cents. To be obtained from the Commissioner of Patents, Washington, D. C. In asking for specifications they should be referred to by number. The Official Gazette of the United States Patent Office (issued weekly and probably to be found in every public library) contains the number and a short description of each patent issued. Annual subscription for Gazette, $5.

GENERAL INFORMATION SERIES:

No. V, pages 231 to 238.

No. VI, page 312.

No. VII, pages 336, 338, 359 to 365.

No. VIII, pages 397 to 402.

No. IX, pages 101 to 113 and 325 to 336, inclusive, being an article entitled "The development of rapid-fire guns for naval use."

No. X, Chap. III.

No. XI, Chap. III.

Copies of these numbers of General Information Series have been furnished to naval officers, and the editions are about exhausted.

SMALL ARMS.

ALLGEMEINE WAFFENKUNDE FÜR INFANTERIE. MIT BESONDERER BERÜCKSICHTIGNUG DER NEUESTEN KRIEGS-HANDFEUERWAFFEN DER MODERNEN STAATEN. Neue Folge von 1891 zum Grundwerke von 1888. Von Rudolf Schmidt, Oberst. Bern: Verlag von Schmidt, Francke & Co. (vorm. J. Dalp'sche Buchhandlung). Tafeln 24–30 mit Abbildungen in Farbendruck. Contains colored plates of the different parts of small arms used in the armies of France, Italy, Holland, Turkey, Austria-Hungary, England, and Switzerland, with descriptions of same. The Danish and Belgian small arms are also described. This work appears in several principal languages, and carries the subject on from 1888.

LES NOUVELLES ARMES À FEU PORTATIVES ADOPTÉES COMME ARMES DE GUERRE DANS LES ÉTATS MODERNES. 1889. Par Rodolphe Schmidt, colonel d'infanterie, directeur de la fabrique fédérale d'armes à Berne. Bale-Geneve-Lyon, H. Georg., libraire-editeur. Description détaillée précedée d'une étude générale des armes d'infanterie et accompagnée d'un atlas contenant 100 figures chromolithographiques. Addition to the above by same author published in 1891, containing drawings and descriptions of latest rifles.

DAS KLEINSTE KALIBER. By Professor Hebler. Zurich. A. Müller.

TREATISE ON MILITARY SMALL ARMS AND AMMUNITION, WITH THEORY ON THE MOTION OF A RIFLE BULLET. 1888. Compiled at the School of Musketry with the assistance of the superintendent's royal laboratory, royal small arms factory, royal gunpowder factory. A text-book for the army. Price, 4*s.*; interleaved, 4*s.* 9*d.* To be obtained either directly or through any bookseller from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., London: Adam & Charles Black, 6 North Bridge, Edinburgh; Hodges, Figgis & Co., 104 Grafton street, Dublin.

ARMIA A RIPETIZIONE. 1890. By Ippolito Viglezzi, lieutenant-colonel of artillery. Published by Voghera Carlo, Rome. May be obtained through B. F. Stevens, No. 4 Trafalgar Square, London. Vol. I, text; Vol. II, plates.

GENERAL INFORMATION SERIES, OFFICE OF NAVAL INTELLIGENCE:

No. VI, pages 136 to 151, "Recent practice in small arms," and 152 and 199, "Musketry instructions at home and abroad."

No. VII, pages 366 to 372.

No. VIII, pages 402 to 412.

No. IX, pages 125 to 130. Development of rapid-fire guns.

No. X, Chap. III.

No. XI, Chap. III.

PROJECTILES.

TREATISE ON AMMUNITION. 1887. Chapters 13 to 20 inclusive. Printed by order of the Secretary of State for War. Price, 6*s.* London: Harrison & Sons, St. Martins Lane. Can be purchased either directly or through any bookseller from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., or Adam & Charles Black, North Bridge, Edinburg; or Hodges, Figgis & Co., 104 Grafton street, Dublin. Fourth edition corrected to January 1, 1887.

COURS D'ARTILLERIE. LES PROJECTILES. 1881. Par. E. Jouffret, chef d'Escadron d'Artillerie Fontainebleau. Typographie de Ernest Bourges, imprimeur di l'Ecole d'Application, 32 Rue de l'Arbre-Sec. Used at the l'Ecole d'Application et d'Artillerie et du Genie.

LE NOUVEAU MATERIEL NAVAL. Vol. I. 1889. Chap. III, pp. 127-156. See books under heading Miscellaneous.

UNITED STATES PATENT SPECIFICATIONS. See under heading Ordnance Rapid-fire Guns.

TACTICS.

THE INFLUENCE OF SEA POWER UPON HISTORY; 1660-1783. 1890. By Capt. A. T. Mahan, U. S. Navy. Boston: Little, Brown & Co. "The definite object proposed in this work is an examination of the general history of Europe and America with particular reference to the effect of sea power upon the course of that history. * * * It is easy to say in a general way that the use and control of the sea is and has been a great factor in the history of the world; it is more troublesome to seek out and show its exact bearing at a particular juncture. Yet unless this be done the acknowledgment of general importance remains vague and unsubstantial; not resting as it should upon a collection of special instances in which the precise effect has been made clear by an analysis of the conditions at given moments. * * * The present work aims at putting maritime interests in the foreground, without, however, divorcing them from their surroundings of cause and effect in general history, but seeking to show how they modified the latter and were modified by them. * * * Writing as a naval officer in full sympathy with his profession, the author has not hesitated to digress freely on questions of naval policy, strategy, and tactics; but as technical language has been avoided it is hoped that these matters simply presented will be found of interest to the young professional reader."

NAVAL WARFARE: ITS RULING PRINCIPLES AND PRACTICE HISTORICALLY CONSIDERED. 1891. By Rear Admiral P. H. Colomb, Gold Medalist Royal United Service Institution and Lecturer on Naval Strategy and Tactics at the Royal Naval College at Greenwich. London: W. H. Allen & Co., limited, 13 Waterloo Place, and at Calcutta. The eighteen chapters treat of the following subjects:

The nature of naval war.
The struggle for the command of the sea.
The differentiation of naval force.
Attempts to gain command of the sea, with definite ulterior purpose.
The conditions under which attacks on territory from the sea succeed or fail.
Attacks on territory from the sea.

THE GUN, RAM, AND TORPEDO. 1885. By Commander Gerard H. U. Noel, R. N. Price, 8*s.* 6*d.* Portsmouth: Griffin & Co., No. 2 The Hard. London agents: Simpkin & Co. Manœuvres and tactics of a naval battle in the present day. The influence of modern ships and guns, rams, torpedoes, and other weapons on a naval action in the open sea. Prize essay. Written in competition for the prize of the Junior Naval Professional Association. With numerous illustrations. Second edition with author's preface.

PROBLEMS IN NAVAL TACTICS. 1879. By Vice-Admiral Randolph. Price, 2*s.* Portsmouth: Griffin & Co., No. 2 The Hard. London agents: Simpkin, Marshall & Co.

REMARKS ON THE MANŒUVRES OF TWO VESSELS IN ACTION. 1881. By Lieut. G. R. Bethell, R. N. Price, 2*s*. Portsmouth: Griffin & Co., No. 2 The Hard. London agents: Simpkin, Marshall & Co.

EXAMPLES, CONCLUSIONS, AND MAXIMS OF MODERN NAVAL TACTICS. 1884. By Commander William Bainbridge-Hoff, U. S. Navy. Washington: Government Printing Office. No. III of the General Information Series of the Office of Naval Intelligence, U. S. Navy Department. Published also by Griffin & Co., No. 2 The Hard, Portsmouth, England. Price, 10*s*. 6*d*.

A TREATISE ON FUTURE NAVAL BATTLES AND HOW TO FIGHT THEM, AND ON OTHER NAVAL TACTICAL SUBJECTS. 1885. G. Elliot. Price, 14*s*. 122 pp., 8vo., with 25 plates and 6 maps. Chapter I. Line-of-battle ships and torpedo vessels. Chapter II and III. Ram and Gun Attack and Defense. Chapter VII. Practical remarks on designs for ships of war. Chapter IX. Cellular Deck Protection, etc.

COAST DEFENSE BY GUNBOATS. 1887. By G. Elliot. Price, 7*s*. 21 pp., 8vo., with 1 plate and 7 figures. Published by the Journal of the Royal United Service Institution. See under Miscellaneous; Periodicals.

LECTURE ON THE TURNING POWERS OF SHIPS. 1882. By W. H. White, Assistant Constructor, R. N. Government Printing Office, Washington. Reprinted as Navy Scientific Paper No. 7, from the Journal of the Royal United Service Institution. May be obtained from the Bureau of Equipment, Navy Department.

THE RAM. THE PROMINENT FEATURE OF FUTURE NAVAL VICTORIES. 1884. By George Elliot. Price, 5*s*. London: Published by the Journal of the Royal United Service Institution. See under Miscellaneous; Periodicals.

SPEED, TURNING, AND MANŒUVERING TRIALS FOR VESSELS OF THE UNITED STATES NAVY. GENERAL ORDER NO. 314. 1883. Washington: Government Printing Office.

THE DUEL. A NAVAL WAR GAME. Invented and arranged by Capt. Philip H. Colomb, R. N. Price, 10*s*. 6*d*. Portsmouth, England: Griffin & Co., No. 2 The Hard. London agents: Simpkin, Marshall & Co. Explanations and rules of the game, and the necessary scales and large drawing blocks.

HINTS ON ANCHORING AND MOORING WITH THE FLEET. By Staff Commander B. Gwynne. Price, 1*s*.

FLEET MANŒUVRING. By Pellews. Price, 12*s*. 6*s*. Portsmouth, England: Griffin & Co., No. 2 The Hard.

ESSAY ON TACTICS IN AN ACTION ON THE OPEN SEA WITH EXISTING WEAPONS. By Lieut. Campbell, R. N. Price, 2*s*. London: Harrison & Sons, 59 Pall Mall, S. W. 8vo. Sewn.

NAVAL TACTICS. Translated from the French by Capt. Augustus Phillimore. Price, 10*s*. London: Harrison & Sons, 59 Pall Mall, S. W. Contains general instructions, principles of chasing, naval tactics under steam and sail. 8vo, cloth.

LES TORPILLEURS, LA GUERRE NAVALE ET LA DEFENSE DES CÔTES. 1888. Par le Vice-Amiral Bourgois. Paris: Librarie de la Nouvelle Revue, 18 Boulevard Montmartre. Deuxieme edition. Nouvelles Bases de Tactique Navale. Par l'Amiral Gregoire Boutakov. Traduit du russe par H. de la Planche, lieutenant de vaisseau. Paris: Arthus Bertrand, editeur, Librarie Maritime et Scientifique, Rue Haute Feuille, 21. Ouvrage couronne par l'Academie des Sciences de St. Petersbourg, publie par ordre de S. Exc. le Marquis de Schassloup-Laubat, Ministre de la Marine et des Colonies. Accompagnie de 26 planches gravees, dont 15 en coleur, et de nombreusses figures intercalees dans le texte.

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PROFESSIONAL PAPERS OF THE CORPS OF ENGINEERS, U. S. ARMY, NO. 23. REPORT UPON EXPERIMENTS AND INVESTIGATIONS TO DEVELOP A SYSTEM OF SUBMARINE MINES FOR DEFENDING THE HARBORS OF THE UNITED STATES. 1881. Submitted to the Board of Engineers by Lieut.-Col. Henry L. Abbot, Corps of Engineers, brevet brigadier-general U. S. Army, member of the Board. Washington; Government Printing Office.

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Termes de Marine Anglais-Français. 1890. Par Léon Delbos, professeur a l'École Navale Anglaise. Prix 4 frans. Paris Publié par L. Boudoin et Cie, 30 Rue Dauphine. Deuxième édition. 1 vol in 12 relié. Notes et Tableaux, a l'usage des officiers de la flotte et des élèves des écoles navales.

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INDEX.

A.

Page.
Accumulators on board ship 194
Actif 37
Adamson R. F. gun 101
Administration, naval, notes on 161
Adventure 12
Æolus 13
Aitodor 47
Ajax 10
Alarme 38
Alarm gongs 209
Albatross 36
Alcyone 37
Alfonso XIII 51
Alger 34
Algerine 24
Algésiras, torpedo schoolship, France 175
Almirante Lynch, bursting of 14-pounder Hotchkiss R. F. gun 92
Amiral Duperré 34
Ammunition hoist, Schneider's 109
Anapa 47
Ancona 43
Andrea Doria, defective 68-ton gun 87
Andromache 20
Anson, 67-ton gun 85
Aoraï 37
Apollo 20
Apyrite 138
Aquila 54
Araguary 59
Argentina, ships 59
    small arms 117
Ariel 37
Armor in 1892 271
Armor:
  England—
    Brown-Tresidder, compound 146, 276, 282
    Brown, nickel-steel 282, 286
    Cammell, compound 280, 286, 306
    Cammell, nickel-steel 283, 286, 305
    Vickers, nickel-steel 282, 285
  France—
    Creusot 272, 282, 305
    Marrell Bros 282
    St. Chamond 282
    St. Etienne 282
  United States—
    Bethlehem Iron Co 288, 305, 308
    Carnegie, Phipps & Co 288
Armor, face-hardening treatment, Harvey 144
    Tresidder 146

Page.
Armstrong, guns 83, 87
    R. F. 92, 95, 109
Assaye 23
A squadron, manœuvres, Austria 259
    France 250, 251
Atlante 42
Audace 43
Austria:
  Cellulose 150
  Electric night signals 207
  Guns, machine, Maxim 103
    Skoda 105
    R. F 97
  Manœuvres, naval 259
  Ships 52
  Small arms 117
  Smokeless powder 135
  Torpedoes 130, 134
Automatic governor, dynamo engines 188
Automatic lamp for search light 202
Auxiliaries and boilers of United States vessels, tables of data 66

B.

Baker's submarine boat 9
Balistite 138
Baltimore, data relating to machinery 66
    deterioration of condenser tubes 69
Bancroft 8
Barbillon 37
Barracouta, boiler ferrules 77
Batteries, electrical 195
Bécassine 36
Belize 62
Bellerophon 24
Bellona 55
Benbow, 110½-ton guns 84
Benjamin Constant 58
Beowulf 49
Bergeronnette 36
Berthier carbine 121
Bethlehem Iron Company's armor plates, 288, 305, 308
    nickel-steel 309
Bismarck 49
Bjorke 47
Blake 17
Blanco Encalada 54
Blenheim 17
Blue squadron, English manœuvres 219, 227

Page.

- B N (smokeless powder) 82, 88, 91, 95, 137
- Boat dynamo and engines 187
- Boilers:
  - Ferrules, new type, England 77
  - Notes. (*See* Machinery.)
  - United States vessels, tables of data 66
- Books, list of standard 313
  - Armor 313
  - Chronometers 315
  - Compasses 314
  - Electricity and magnetism 315
  - Explosives 318
  - Hygiene 319
  - International law 320
  - Machinery 323
  - Metallurgy, chemistry, etc 327
  - Meteorology, laws of storms, etc 328
  - Miscellaneous 348
    - Dictionaries 352
    - Foreign service journals and other other periodicals 352
    - Works of reference 348
  - Naval ship-construction 331
  - Navigation, surveying, etc 333
  - Ordnance 336
    - Ammunition 336
    - Guns 336
    - Rapid-fire guns 342
    - Small arms 343
    - Projectiles 343
  - Tactics 344
  - Torpedoes, submarine mines, etc 346
- *Boomerang* 15
- *Borgo* 47
- *Boston*, data relating to machinery 66
- *Boursaint* 36
- *Bouvet* 29
- *Bouvines* 32
- *Brandenburg* 48
- Brennan dirigible torpedo 130
- *Brennus* 31
  - Melinite shells *vs.* top-sides 143, 151
- *Britannia* cadets, number entering yearly 162
- *Britomart* 25
- Brown's emergency gear 76
- B squadron, manœuvres, Austria 259
  - France 251
- Budgets, naval:
  - Argentina 59
  - Austria 52
  - Chile 54
  - Denmark 54
  - England 9
  - France 26
  - Germany 47
  - Italy 41
  - Norway 50
  - Russia 44
  - Spain 50
  - Sweden 57
  - United States 7
- *Bug* 46
- Bulgaria, ships 62
  - small arms 219
- Bursting of *Concord's* steam pipe 67

C.

Page.

- C/89 (smokeless powder) 137
- *Calabria* 41
- *Cambrian* 24
- *Cambridge*, gunnery ship, England 170
- Cammell armor, compound 280, 286, 306
  - nickel-steel 283, 286, 305
- Canet, guns 82, 88
  - R. F. 91, 96, 100
- *Capitan Prat* 54
- Carbines, Berthier 121
  - Männlicher, M/90 117
- Carcano magazine rifle 124
- Carnegie, Phipps & Company's armor plates 288
- *Carpe* 36
- Case engine for boat dynamo 187
- *Cassini* 29
- *Castelfidardo* 43
- *Castine* 8, 63
- Castings, steel 65
- Casualties:
  - Bursting of *Concord's* steam pipe 67
  - During manœuvres 232
  - Guns. (*See* Guns, casualties.)
- Cellulose:
  - French trials, using melinite shells 151
  - *Hekla* firing trials 150
  - United States coffer-dam tests 152
- Central station for signals 211
- *Chacul* 36
- *Chamois* 36
- Changes authorized in machinery of United States vessels:
  - *Castine* 63
  - Cruiser No. 6 64
  - Cruisers Nos. 12 and 13 64
  - *Detroit* 63
  - Harbor-defense Ram 65
  - *Indiana* 64
  - *Machias* 63
  - *Marblehead* 63
  - *Massachusetts* 64
  - *Monterey* 63
  - *Montgomery* 63
  - *New York* 64
  - *Oregon* 64
  - *Texas* 63
- *Charles Martel*, ammunition hoist 109
- *Charleston*, data relating to machinery 66
- *Château-Renault* 37
- *Chevalier* 37
- *Chicago*, data relating to machinery 66
- Chief of naval general staff, France 172
- Chile:
  - Guns 82
    - R. F. 91
  - Ships 54
  - Small arms 120
- China:
  - Ships 53
  - Small arms 120
- *Circe* 14
- Classification of men, Italy 177
  - reserve ships, England 170
- *Clio* 42

Page.

- *Coëtlogon* 35
- Coffer-dam cellulose tests, United States 152
- *Cohassett* 8
- *Columbine* 24
- Combination oil and electric light fixtures 199
- Comments on naval manœuvres of Austria 260
  - England 233
  - France 254
  - Germany 258
  - Russia 268
- Compound armor, Brown-Tresidder 146, 276, 282
  - Cammell 280, 286, 306
- *Concord*, bursting of steam-pipe 67
  - data relating to machinery 66
- Condenser tubes, deterioration of *Baltimore's* 69
- *Constance* 14
- Converted R. F. guns, France 94
- *Corale* 30
- *Cordelia*, bursting of a 6-inch B. L. R 85
- Cordite 136
- *Cormoran* 49
- Corpo reali equipaggi, Italy 176
- *Corsaire* 37
- *Cosmao* 35
- Costa Rica, ships 62
- *Courlis* 37
- *Crescent* 13
- Creusot nickel-steel 272, 282, 305
- Cruiser No. 6, changes in machinery 64
- Cruisers Nos. 12 and 13, changes in machinery 64
- *Cuervo* 58
- Cuniberti liquid-fuel system 79
- *Curlew* 14

D.

- *Dago* 47
- Dashiell R. F. gun 101
- Data relating to machinery of United States vessels, tabulated 66
- *Davout* 34
- Deck-armor tests 282
- *Defense* 62
- Defense squadron, naval manœuvres, Russia 262
- *Defiance*, torpedo training ship, England 170
- Denmark:
  - Cellulose trials 150
  - Machine guns 104
  - Ships 54
  - Smokeless powder 135
  - Torpedoes 130
- Depots, general, for men, England 170
- *Despatch* 8
- *Dessalines* 62
- *Destroyer*, submarine gun 131
- Deterioration of *Baltimore's* condenser tubes 69
- *Detroit* 7, 63
- *Devastation* 10
- Devonport, England, gunnery establishment 170
- *D'Iberville* 29
- Dimensions of boat dynamos and engines 187

Page.

- Dimensions of standard electrical generating sets, U. S. Navy 186
- Discharging apparatus, torpedo 134
- Dockyard reserve, ships, England 171
- *Dolphin*, data relating to machinery 66
- *Dordogne* 36
- Double bottoms, ventilation of 194
- Draft, forced:
  - Boiler ferrules of new type for use with 77
  - Induced draft to be fitted in *Gossamer* 78
- *Dragon* 24
- Driggs-Schroeder R. F. guns 93
- *Dryad* 10
- *Dunai* 46
- *Dupuy de Lôme* 35
- Dynamo room, location of 192
  - ventilation of 194

E.

- *Éclair* 38
- *Edgar* 18
- Efficiency of standard electrical generating sets, United States Navy 186
- *Ekness* 47
- *Elba* 41
- Electric batteries 195
  - launches 47
  - lights, incandescent 200
  - night signals 205
- Electrically controlled projectors 201
- Electricity on board naval vessels 185
- Elswick pedestal R. F. gun mount 109
- *Emeraude* 30
- Emergency gear, Brown's 76
- *Endymion* 13
- Engines:
  - For dynamos, regulation 188
    - tests for regulation 190
  - Notes. (*See* Machinery.)
  - U. S. vessels:
    - Changes authorized 63
    - Tables of data 66
- England:
  - Armor 66, 276, 280, 282, 285, 305
  - Boiler ferrules, new type 77
  - Electric night signals 207
  - General depots for men 170
  - Gun mounts 107
  - Gunnery training establishments 169
  - Guns 82
    - machine 104
    - R. F 92
  - Lyddite 142
  - Manœuvres, naval 213
  - Personnel notes 161
  - Projectiles 159
  - Royal naval artillery volunteers 168
  - Royal naval reserve 164
  - Ships 9
  - Ships in reserve, classification 170
  - Small arms 120
  - Smokeless powder (Cordite) 136
  - Torpedo discharging apparatus 134
    - net cutters 134
  - Torpedoes 128, 130, 133

Page.

- *Enterprise* 24
- *Ercole* 42
- Ericsson submarine gun 131
- *Erzherzog Albrecht* 52
- *Étendard* 36
- *Etruria* 41
- *Excellent*, gunnery ship, England 169
- Exercises for torpedo boats, France 174
- Experiments:
  - Liquid fuel, Italy 79
  - Vibration of vessels, Yarrow on 72
- External magnetic field of dynamos, tests of 190

F.

- Face-hardening treatments for armor:
  - Harvey 144
  - Tresidder 146
- *Falke* 49
- *Favorite* 36
- Ferrules, boiler, new type, England 77
- *Filibustier* 37
- Fire alarms 209
- Fiske's position-finder 155
- Fixtures, electric light 199
- *Flamingo* 25, 55
- Fleet reserve, ships, England 171
- Fletcher R. F. gun mount 112
- *Flink* 50
- *Fontenoy* 36
- Forced draft. (*See* Draft, forced.)
- *Foudre* 29
- France:
  - Armor 272, 282, 305
  - Cellulose 151
  - Electric night signals 207
  - General staff, naval 172
  - Guns 86
    - machine 104
    - R. F 94
  - Manœuvres, naval 241
  - Melinite 142, 151
  - Personnel notes 172
  - Promotion law, proposed, status 174
  - Schneider ammunition hoist 109
  - Ships 26
  - Small arms 121
  - Smokeless powder 137
  - Squadrons in home waters 175
  - Superior naval council 173
  - Torpedo-boat drills 174
  - Torpedoes 131
- *Francis Garnier* 37
- *Frithjof* 47
- Fuel, liquid, Italian experiments 79

G.

- *Galicia* 51
- Gâvres, armor trials at 272
- *Geiser* 55
- General depots for men, England 170
- General service corps, Italy 176
- General staff, naval, France 172
- Generating sets, electrical 186
  - number and size of 191
  - tests of 188

Page.

- *George the Conqueror* 45
- Germany:
  - Administrative measures 183
  - Electric night signals 207
  - Guns 167
    - machine 103
    - R. F 97
  - High explosives 144
  - Krupp's mounts for R. F. guns 110
  - Manœuvres, naval 256
  - Personnel, notes 183
  - Search lights 202
  - Ships 47
  - Small arms 124
  - Smokeless powder 137
- *Gibraltar* 13
- *Gleaner* 23
- *Gogah* 36
- *Gondal* 58
- *Gossamer* 23, 78
- *Goubet* 40
- Governors for dynamo engines 188
- *Grafton* 13
- Greece, small arms 124
- *Gremiastchi* 46
- Grenfell's illuminated night-sights 159
- *Griden* 46
- *Griffon* 24
- *Grondeur* 38
- *Gudur* 58
- Gun mounts:
  - England—
    - Casualties 108
    - Elswick pedestal R. F. gun 109
    - *Royal Sovereign*, trial of 107
    - Vavasseur's housing apparatus 108
  - Germany—
    - Krupp R. F 110
  - Spain—
    - Schneider c. p. for 14 cm gun 111
  - United States—
    - Navy 4-inch R. F. gun 112
- Gunnery training establishments, England 169
- Guns:
  - *Anson's* 67-ton 85
  - Armstrong 83, 87
  - *Benbow's* 110½-ton 84
  - Canet 82, 88
  - Casualties—
    - *Almirante Lynch* 92
    - *Andrea Doria* 87
    - *Anson* 85
    - *Benbow* 84
    - *Cordelia* 85
    - *Howe* 85
    - Horten 89
    - Ochta 100
    - *San Martino* 100
    - *Sanspareil* 84
    - *Victoria* 84
  - Chile 82
  - England 82
  - France 86
  - Germany 87
  - High-power 81

Guns—Continued. Page.

- Hontoria 100
- *Howe's* 85
- Italy 87
- Japan 88
- Krupp 87, 89
- Norway 89
- Ordoñez 90
- Russia 89
- *Sanspareil's* 84
- Spain 90
- Submarine, Ericsson's 131
- United States 90
- *Victoria's* 84
- Wire-wound 83

Guns, machine 103
- R. F. 91

Gustave Zédé 40

Gymnote 40

H.

Habsburg 52

Hadfield a. p. projectiles 159

Haiti, ships 62

Halcyon 10

Handy 169

Harbor-defense Ram, changes in machinery 65

Harpy 24

Harrier 10

Harvey, face-hardening treatment for armor 144
- nickel-steel 309
- trials of treated plates 287

Hawke 18

Hay 183

Haysal 47

Hazard 10

Heating of dynamo circuits, tests of 189

Hebe 14

Heimdal 55

Hekla, cellulose trials 150

Helm indicators 209

Hercules 16

Héroïne 37

Het Loo, trials of R. F. guns 99

High explosives:
- Explosive gelatine 140
- Lyddite 142
- Melinite 142

High-power guns 81

Hjälperen 55

Hohenzollern 49

Holland:
- Guns, R. F. 99
- Ships 55
- Small arms 124

Hood 12

Hostile squadron, naval manœuvres, Russia 261–265

Hotchkiss R. F. gun, bursting of 14-pounder 92

Housing apparatus, Vavasseur's 108

Howell fish torpedo 131

Howe's 67-ton gun 85

Hunt, A. M., report on *Baltimore's* condenser tubes 70

Hussar 10

I.

Page.

Iguatemy 59

Illuminated night sights, Grenfell's 159

Incandescent electric lights 200

Indefatigable 20

Indiana, armor reception test 308
- changes in machinery 64

Indian head armor trials 287

Induced draft, to be fitted in *Gossamer* 78

Infernet 36

Insulation of electrical conductors 196

Insulation resistances of dynamo circuits, measurement of 188

Intrepid 20

Intrépide 36

Iphegenia 13

Iride 42

Italy:
- Electric night signals 207
- Experiments, liquid fuel, in torpedo boat No. 104 79
- General service corps 176
- Guns 87
  - machine 104
- Personnel notes 176
- Promotion law, proposed 178
- Ships 41
- Small arms 124
- Smokeless powder 138
- Squadrons in home waters 182
- Standard electrical apparatus 186
- Torpedo-boat trials, duration of 79

Itzvar 47

Iwana 8

J.

Japan:
- Guns, Canet 88
- Ships 56

Japon 175

Jaseur 10

Jason 10

Jean Bart 34

Jemchug 46

Jemmapes 32

Jumna 25

Junction boxes, electrical 197

Jururema 59

Justin high-explosive shells 140

Jutahy 59

K.

Kabyle 38

Kaiser 52

Kaiseradler 49

Kaiserin Augusta 48

Kaiserin Elizabeth 52

Kaiser Max 52

Karrakatta 15

Katka 47

Kazan 44

Keyboard for electric night signals 206

Keyham engineering college, total number of students 162

Kieff 44

Page.

- *Kondor* 49
- *Körös* 52
- *Koursk* 44
- *Kronschlot* 47
- Krupp, guns 87, 89
  - R. F 97
  - mounts 110
- *Kuang Keng* 53
- *Kuang Ping* 53
- *Kuang Ting* 53
- *Kuang Yi* 53
- *Kühn* 50
- *Kurfürst Friedrich Wilhelm* 47

L.

- *Lamothe-Piquet* 36
- *Lansquenet* 37
- Lanterns for electric night signals 207
- *Latona* 20
- Lee improved rifle 120
- *Léger* 35
- *Lévrier* 35
- *Liguria* 41
- *Lima* 61
- *Linois* 28
- Liquid fuel, Italian experiments 79
- *Lissa* 52
- *Lombardia* 41
- *Lombok* 56
- Lyddite 142

M.

- *Machias* 8, 63
- Machine guns, Maxim 103
  - Skoda 105
- Machinery, notes on 63
  - United States vessels, tables of data 66
- Magazine rifles 115
- Maitland liners 83
- Mannlicher small arms 116, 117, 119, 120, 124, 126
- Manœuvres. (*See* Naval Manœuvres.)
- *Marblehead*, changes in machinery 63
- *Marcilis Dies* 59
- *Marco Polo* 41
- *Maria Pia* 43
- *Marne* 36
- Marrel Bros., gun shields 274
- *Mars* 183
- Martini-Henry, small arms 121, 128
- Martin system induced draft to be fitted in *Gossamer* 78
- *Massachusetts*, changes in machinery 64
- *Massena* 29
- *Matsushima* 56
- Mauser small arms 116, 117
- Maxim automatic machine guns 103
- Maxim-Nordenfelt semi-automatic gun 97
- Means of interior communication on board naval vessels 209
- Mediterranean fleet, naval manœuvres, France 242
- *Melampus* 20
- Melinite 142

Page.

- *Mildura* 15
- *Minerva* 42
- *Miranda* 25
- Molding for electric light wires 198
- *Monarch* 10
- *Monterey*, changes in machinery 63
- *Montgomery* 7, 63
- *Moonsund* 47
- *Moriak* 45
- Motors, electric 207
- *Mousquetaire* 37
- Mouzin magazine rifle 126
- Multiple connection of dynamos 188, 192
- *Musquito* 49

N.

- *Naiad* 20
- *Naide* 52
- *Narkeeta* 8
- Naval administration, Notes on:
  - England 161
  - France 172
  - Germany 183
  - Italy 176
- Naval artillery volunteers, Royal 168
- Naval budgets. (*See* Budgets, naval.)
- Naval general staff, France 172
- Naval Manœuvres, 1891:
  - Austria:
    - A Squadron 259
    - B Squadron 259
    - Comments 260
    - Idea 259
  - England:
    - Blue Squadron, vessels of 219
      - operations of 227
    - Casualties 232
    - Comments 233
    - Mobilization 219
    - Northern Fleet, vessels of 217
      - operations of 220
    - Orders, general 213
      - Introductory cruise, section II 214
      - Landing of wounded, section VI 216
      - Manœuvre cruises, section III 214
      - Memorandum, section V 215
      - Operations, section III 214
      - Target practice, section IV 215
    - Red Squadron, vessels of 218
      - operations of 227
    - Western Fleet, vessels of 218
      - operations of 225
  - France:
    - A Squadron, vessels of 250
      - operations of 251
    - B Squadron, vessels of 251
      - operations of 251
    - Comments 254
    - General idea of operations 246
    - Mediterranean Fleet, vessels of 242
      - operations of 243
    - Rules 246
    - Umpires 246

Naval Manœuvres, 1891—continued.

Page.

- Germany:
  - Comments 258
  - Operations 257
  - Squadron of Evolution 257
    - Manœuvres 257
- Russia:
  - Comments 268
  - Defense Squadron, vessels of 262
    - operations of 266
  - General idea 262
  - Hostile Squadron, vessels of 261
    - operations of 265
  - Rules 263

- Naval reserve, Royal 164
- *Navarino* 45
- *Neptune* 33
- Nesbitt's vibrometer 72
- Net-cutting attachments 134
- *Nettle*, armor trials 279, 283, 284, 285
- *Newark*, data relating to machinery 66
- *New York* 8
  - Changes in machinery 64
  - Electrical energy for 191
- Nickel-steel armor 309
  - Bethlehem Iron Co 301, 303, 305, 308
  - Carnegie, Phipps & Co 293, 295, 297, 299
  - Cammell & Co 283
  - Creusot 272
  - Vickers 283, 285
- *Niger* 10
- Night-sights, Grenfell's 159
- *Nobo* 56
- Northern fleet, naval manœuvres, England 217, 220
- Norway:
  - Guns 89
  - Ships 57
- Notes:
  - Machinery 63
  - Naval administration and personnel 161
  - Ordnance 81
  - Ships, Argentina 59
    - Austria 52
    - Brazil 58
    - Bulgaria 62
    - Chile 54
    - China 53
    - Costa Rica 62
    - Denmark 54
    - England 9
    - France 26
    - Germany 47
    - Haiti 62
    - Holland 55
    - Italy 41
    - Japan 56
    - Mexico 61
    - Norway 57
    - Peru 61
    - Portugal 58
    - Roumania 62
    - Russia 44
    - Siam 62
    - Spain 50
    - Sweden 57
    - Turkey 61
    - United States 7

O.

Page.

- Officers:
  - Laws, proposed, relating to—
    - France 174
    - Italy 178
  - Retirement, note concerning, England 164
  - Royal naval artillery volunteers 168
  - Royal naval reserve 166
  - Special class, subordinate, Italy 176
- *Olaf* 46
- *Onyx* 10
- *Opal* 25
- *Oquendo* 50
- *Orago* 38
- Ordnance:
  - Instruments:
    - Fiske's position-finder 155
    - Illuminated night-sights 159
    - Telescopic sight 158
  - Notes on 81
- Ordoñez guns for Spain 90
- *Oregon*, changes in machinery 64
- *Orenburg* 44
- *Orm* 57
- *Orontes* 25
- *Oter* 57
- *Otvagenii* 46
- *Ouessant* 36
- *Oyapock* 37

P.

- *Pacifique* 36
- *Pathan* 26
- P. C. /89 (smokeless powder) 139
- Pedestal R. F. gun mount, Elswick's 109
- *Pegasus* 24
- *Pelikaan* 55
- *Pelikan* 52
- *Pensa* 44
- *Perle* 36
- Personnel, notes on—
  - England 161
  - France 172
  - Germany 183
  - Italy 176
- Peru, ships 61
- *Petrel*, data relating to machinery 66
- Petroleum refuse fuel, Italian experiments 79
- *Petropavlovsk* 44
- *Philadelphia*, data relating to machinery 66
- *Phlégéton* 34
- *Pioneer* 12
- *Pique* 20, 36
- *Planet* 53
- *Plassy* 23
- *Pocadnick* 44
- *Polarnaia-Svesda* 46
- *Poltava* 44
- *Pomerania* 49
- Portable ventilating sets 194
- Port guard ships, England 170
- Portsmouth, England, gunnery establishment 169
- Portugal, ships 58
- Position-finder, Fiske's 155
- *Pothuan* 28

Page.

Powder, smokeless ... 135
Presidente Pinto, trial of Canet R. F. guns ... 91
Princess Wilhelm ... 49
Procris ... 25
Projectiles, Hadfield, a. p ... 159
Projectors, search light ... 200
Promotion laws, proposed:
  France ... 174
  Italy ... 178
Protective decks, melinite shells *vs* ... 143
Provence ... 36
Pullini's submarine boat ... 43

R.

Rainbow ... 20
Raleigh ... 8
Ramillies ... 12
Ranger ... 24
Rapid-fire guns:
  Adamson ... 101
  Armstrong ... 92, 95, 109
  Canet ... 91, 96, 100
  Chile ... 91
  Dashiell ... 101
  Driggs-Schroeder ... 93
  England ... 92
  France ... 94
  Germany ... 97
  Krupp ... 97
  Maxim-Nordenfelt semi-automatic ... 97
  M. /81 T. R ... 94
  Nordenfelt ... 100
  Rodriguez ... 100
  Russia ... 100
  Spain ... 100
  Sweden ... 101
  Thronsen ... 101
Rapido ... 51
Receptacle, electrical ... 198
Reception test, 14-inch nickel-steel ... 308
Recoil check, Schneider's ... 114
Red Squadron, naval manœuvres, England ... 218, 227
Regulation of dynamo engines ... 188
Reinier Clæsen ... 55
Renard ... 10
Republica ... 59
Repulse ... 12
Requirements for standard electrical generating sets, U. S. Navy ... 186
Reserve, ships, classification, England ... 170
Reserves, personnel, England:
  Royal naval artillery volunteers ... 168
  Royal naval reserve ... 164
Residuum, petroleum, Italian experiments ... 79
Resolution ... 12
Retirements, note on, England ... 164
Retribution ... 13
Re Umberto ... 41
Revenge ... 13
Revolution indicators ... 209
Riazan ... 44
Riddesmouth, trial of Cammel armor at ... 231
Ringarooma ... 15
Rjukan ... 57

Page.

Rochensalm ... 47
Rodriguez R. F. guns ... 100
Roumania:
  Ships ... 62
  Small arms ... 126
Royal Arthur ... 13
Royal naval artillery volunteers ... 168
Royal naval reserve:
  Numbers to be increased ... 162
  Report on, partial abstract ... 165
  Utilization, admiralty view ... 166
Royal Oak ... 13
Royal Sovereign ... 15
  Boiler ferrules ... 77
  Gun mounts, trial of ... 107
  Torpedo tubes ... 135
Rupert ... 10
Rurik ... 46
Russia:
  Guns ... 89
    mounts ... 111
    R. F. ... 100
  Naval manœuvres ... 261
  Ships ... 44
  Small arms ... 126
  Smokeless powder ... 138

S.

St. Chamond gun shield ... 274
St. Étienne gun shield ... 131
St. George ... 13
Salamander ... 52
San Francisco, data relating to machinery ... 66
San Martino ... 43
  Accident to Nordenfelt R. F. gun ... 100
Sanspareil, 110 ½-ton guns ... 84
Santa Rosa ... 61
Sapphire ... 25
Saratov ... 46
Sardegna ... 41
Satellit ... 52
Scharf ... 50
Schneider:
  Ammunition hoist ... 109
  c. p. mount for Spain ... 111
  Recoil check ... 114
Schutze ... 50
Schwartzkopff fish torpedo ... 131
Scylla ... 13
Search-light projectors ... 200
Seeadler ... 49
Seignelay ... 36
Serpen ... 57
Seskar ... 47
Sevastopol ... 44
Shadié ... 61
Shah ... 25
Sheerness, England, gunnery establishment 170
Ships, notes on ... 7
    reserve, England ... 170
Shoeburyness, armor trials at ... 276, 278, 286, 306
Siam, ships ... 62
Sicher ... 50
Sicilia ... 41

Page.
Siemens-Belliss generating set 188
Sights, Grenfell's illuminated night 159
Signals, electric 205
Silatsch 45
Sims-Edison dirigible torpedo 128
Sirius 20
Sirubirsk 44
Sisoï Veliki 44
Skoda machine gun 105
Small arms 115
Smokeless powder:
  Apyrite 138
  Austria, M / 90 135
  B. N. 137
  Balistite 138
  C / 89 137
  Cordite 136
  Danish 135
  P. C. / 89 139
  Russian 138
  Spanish 138
  United States 140
Solimoes 59
Snyder high-explosive shells 141
Spain:
  Electric night signals 207
  Guns, Ordoñez 90
    mounts 111
    R. F. 100
  Ships 50
  Small arms 127
  Smokeless powder 138
  Torpedoes 131
Spartan 20
Speedwell 24
Speedy 10
Springeren 55
Squadron of evolution, naval manœuvres, Germany 257
Squadron of manœuvres, naval manœuvres, Germany 257
Standard electrical apparatus, U. S. Navy 185
Standard electrical generating sets, U. S. Navy 186
Steam pipe, bursting of *Concord's* 67
Steam reserve, England 171
Steam trials, ships:
  Austria 53
  Chili 54
  England 14
  France 33
  Germany 49
  Holland 56
  Italy 42
  Japan 56
  Spain 51
  United States, tabulated 66
Steel castings 65
Styx 33
Submarine gun, Ericsson's 131
Suffren 34
Sultan 10
Sumbawa 55
Svenskund 57
Svetlana 46

Page.
Sweden:
  Guns, R. F. 101
  Ships 57
  Smokeless powder 138
Swinger 24
Switch and receptacle, electrical 198
Switchboard, standard 195
Switzerland:
  Guns, machine 104
  Smokeless powder 139
Sybille 20
Symonds, Sir Thomas, on personnel 162
Szamos 52

T.

Tables of data relating to machinery of United States vessels 66
Tallapoosa 8
Tambov 44
Tauranga 15
Taylor, D. W., on vibration of steamers 76
Teffé 59
Tegetthoff 52
Telegraphs, engine and helm 209
Telephones 209
Temeraire 10
Temerario 51
Terpsichore 20
Tersichore 41
Testing electrical conductors 196
Testing generating sets 188
Texas 8, 63
Thermostats 211
Thetis 20
Thorne 60
Three Saints 44
Thulé 57
Thunderer 16, 77
Tigre 36
Tirendentes 59
Tocantins 59
Topaze 30
Torpedo boat No. 76, England, attack with 133
  No. 104, Italy, trials with liquid fuel 79
Torpedo boats, exercises, France 174
  notes on, Argentina 60
    Brazil 59
    Costa Rica 62
    Denmark 55
    England 25
    France 37
    Germany 50
    Holland 56
    Italy 43
    Japan 56
    Norway 57
    Portugal 58
    Russia 46
    Spain 51
    Sweden 58
Torpedo-boom attack 133
Torpedo discharging apparatus 134
  net-cutting attachments 134

Page.

- Torpedoes:
  - England 130
  - Ericsson's submarine gun 131
  - France 131
  - Howell, fish 131
  - Sims-Edison, dirigible 128
  - Spain 131
  - United States 131
  - Whitehead, fish 129
- *Toula* 44
- *Tourmante* 37
- Training ships, naval, England, number of boys entering yearly 162
- Tresidder armor face hardening treatment 146
- Tresidder-Brown, trial armor plates 276, 282
- Trials:
  - Armor:
    - England 275
    - France 272
    - United States 287
  - Guns:
    - Chile 82
    - Japan 88
    - Machine, Maxim 104
    - Mounts, *Royal Sovereign* 107
    - R. F., Canet 91
      - Driggs-Schroeder 93
      - Krupp 99
    - Submarine, Ericsson's 131
  - Ships. (*See* Steam Trials.)
- *Tribune* 20
- *Turco* 39
- Turkey:
  - Ships 61
  - Small-arms 128
- *Turquoise* 25
- *Tyrian* 25

U.

- *Umbria* 41
- United States:
  - Armor trials 287, 309
  - Cellulose trials 152
  - Ericsson's submarine gun 131
  - Guns 90
    - Reception test 14-inch nickel-steel 308
    - R. F 101
      - mount 112
  - Machinery 63
  - Ships 7
  - Smokeless powder 140
  - Torpedoes 131
- *Urania* 42

V.

- *Variaghe* 46
- Vavasseur's housing apparatus 108
- *Veloce* 38
- Ventilating sets 194
- *Vernon*, torpedo training ship, England 170

Page.

- *Vesuvius*, data relating to machinery 66
- *Viatka* 44
- Vibration of vessels 72
- Vibrometer, Nesbitt's 72
- Vickers nickel-steel armor 283, 285
- *Victoria* 110½-ton guns 84
- *Vigilant* 36
- *Viking* 57
  - Bursting of 15 cm Krupp gun 89
- *Vizcaya* 50
- *Vivid* 12
- *Voevoda* 44
- Voice pipes 209
- *Volage* 36
- *Volcano* 24
- *Volta* 37
- *Voronej* 44
- *Vorwarts* 50
- *Vulcan* 19
  - Boiler ferrules 77
  - Torpedo discharging apparatus 135

W.

- *Wahneta* 8
- *Wallaroo* 15
- *Wanderer* 25
- *Warren Hastings* 12
- Water alarms 209
- Water consumption, dynamo engines, tests for 191
- *Wattignies* 35
- Weight of boat-dynamo, and engine 187
- Weights of standard electrical generating sets, U. S. Navy 186
- *Weissenburg* 47
- Western fleet, naval manœuvres, England 218, 225
- Whale Island gunnery establishment 169
- White, W. H., on structural strength of ships 11
  - on speed of ships 17
- Whitehead torpedoes:
  - Discharging apparatus 134
  - Fish
    - England 130
    - France 131
- Wire-wound guns 83
- Wiring accessories, electrical 197
- Wiring, electrical 196

Y.

- *Yakoute* 44
- Yarrow, A. F., on vibration of vessels 11, 72
- *Yorktown*, data relating to machinery 66

Z.

- *Zabava* 46
- *Zaragoza* 61
- *Zeehond* 55
- *Zouave* 38

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